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U. S. DEPARTMENT OF AGRICULTURE.

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FARMERS' BULLETIN 340.

DECLARATION OF GOVERNORS FOR CONSERVATION OF NATURAL RESOURCES.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1908.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Forest Service,
Washington, D. C., October 28, 1908.

Sir: Believing that the Declaration of Governors adopted at the recent conference on conservation of our natural resources is worthy of the widest circulation among the people, and that it will do more than anything else that could be published to arouse a popular interest in this very important subject, I respectfully recommend its issuance as a Farmers' Bulletin.

Respectfully,

Gifford Pinchot,
Forester.

Hon. James Wilson,
Secretary of Agriculture.

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DECLARATION OF GOVERNORS FOR CONSERVATION OF NATURAL RESOURCES.

INTRODUCTION.

The Declaration of Governors contained in this bulletin was adopted by the conference of governors of the States and Territories called by the President to consider the conservation of our natural resources, and which met at the White House May 13, 14, and 15, 1908. Besides the governors there were invited to the conference the members of the Cabinet, the justices of the Supreme Court, the members of both Houses of Congress, representatives of the great national organizations, the Inland Waterways Commission, and, as special guests, Hon. William Jennings Bryan, Mr. James J. Hill, Mr. Andrew Carnegie, and Mr. John Mitchell. The late ex-President Grover Cleveland was also invited as a special guest, but illness prevented him from attending. At the request of the President each governor brought with him to the conference three citizens from his State or Territory to act as assistants or advisers.

The object of the conference was stated by the President in his letter of invitation to the governors, in which he said:

> It seems to me time for the country to take account of its natural resources, and to inquire how long they are likely to last. We are prosperous now; we should not forget that it will be just as important to our descendants to be prosperous in their time.

Papers which discussed the present state of our various natural resources were read by experts and specialists in each respective line, and these were followed by an open discussion among the governors of the points brought out.

The conference then appointed a committee to draft a declaration, consisting of the following: Governor NEWTON C. BLANCHARD, of Louisiana; Governor JOHN FRANKLIN FORT, of New Jersey; Governor J. O. DAVIDSON, of Wisconsin; Governor JOHN C. CUTLER, of Utah; and Governor MARTIN F. ANSEL, of South Carolina.

This committee prepared and submitted the declaration which follows, and it was unanimously adopted by the conference of governors as embodying their conclusions on the question of conservation.

DECLARATION.

We, the governors of the States and Territories of the United States of America, in conference assembled, do hereby declare the conviction that the great prosperity of our country rests upon the abundant resources of the land chosen by our forefathers for their homes, and where they laid the foundation of this great nation.

We look upon these resources as a heritage to be made use of in establishing and promoting the comfort, prosperity, and happiness of the American people, but not to be wasted, deteriorated, or needlessly destroyed.

We agree that our country's future is involved in this; that the great natural resources supply the material basis upon which our civilization must continue to depend, and upon which the perpetuity of the nation itself rests.

We agree, in the light of the facts brought to our knowledge and from information received from sources which we can not doubt, that this material basis is threatened with exhaustion. Even as each succeeding generation from the birth of the nation has performed its part in promoting the progress and development of the Republic, so do we in this generation recognize it as a high duty to perform our part; and this duty in large degree lies in the adoption of measures for the conservation of the natural wealth of the country.

We declare our firm conviction that this conservation of our natural resources is a subject of transcendent importance, which should engage unremittingly the attention of the nation, the States, and the people in earnest cooperation. These natural resources include the land on which we live and which yields our food; the living waters which fertilize the soil, supply power, and form great avenues of commerce; the forests which yield the materials for our homes, prevent erosion of the soil, and conserve the navigation and other uses of the streams; and the minerals which form the basis of our industrial life, and supply us with heat, light, and power.

We agree that the land should be so used that erosion and soil wash shall cease; and that there should be reclamation of arid and semiarid regions by means of irrigation, and of swamp and overflowed regions by means of drainage; that the waters should be so conserved and used as to promote navigation, to enable the arid regions to be reclaimed by irrigation, and to develop power in the interests of the people; that the forests which regulate our rivers, support our industries, and promote the fertility and productiveness of the soil should be preserved and perpetuated; that the minerals found so abundantly beneath the surface should be so used as to prolong their utility; that the beauty, healthfulness, and habitability of our country should be preserved and increased; that sources of national wealth exist for the benefit of the people, and that monopoly thereof should not be tolerated.

We commend the wise forethought of the President in sounding the note of warning as to the waste and exhaustion of the natural resources of the country, and signify our high appreciation of his action in calling this conference to consider the same and to seek remedies therefor through cooperation of the Nation and the States.

We agree that this cooperation should find expression in suitable action by the Congress within the limits of and coextensive with the national jurisdiction of the subject, and, complementary thereto, by the legislatures of the several States within the limits of and coextensive with their jurisdiction.

We declare the conviction that in the use of the national resources our independent States are interdependent and bound together by ties of mutual benefits, responsibilities, and duties.

We agree in the wisdom of future conferences between the President, Members of Congress, and the governors of States on the conservation of our natural resources with a view of continued cooperation and action on the lines suggested; and to this end we advise that from time to time, as in his judgment may seem wise, the President call the governors of States and Members of Congress and others into conference.

We agree that further action is advisable to ascertain the present condition of our natural resources and to promote the conservation of the same; and to that end we recommend the appointment by each State of a commission on the conservation of natural resources, to cooperate with each other and with any similar commission of the Federal Government.

We urge the continuation and extension of forest policies adapted to secure the husbanding and renewal of our diminishing timber supply, the prevention of soil erosion, the protection of headwaters, and the maintenance of the purity and navigability of our streams. We recognize that the private ownership of forest lands entails responsibilities in the interests of all the people, and we favor the enactment of laws looking to the protection and replacement of privately owned forests.

We recognize in our waters a most valuable asset of the people of the United States, and we recommend the enactment of laws looking to the conservation of water resources for irrigation, water supply, power, and navigation, to the end that navigable and source streams may be brought under complete control and fully utilized for every purpose. We especially urge on the Federal Congress the immediate adoption of a wise, active, and thorough waterway policy, providing for the prompt improvement of our streams and the conservation of their watersheds required for the uses of commerce and the protection of the interests of our people.

We recommend the enactment of laws looking to the prevention of waste in the mining and extraction of coal, oil, gas, and other minerals with a view to their wise conservation for the use of the people, and to the protection of human life in the mines.

Let us conserve the foundations of our prosperity.

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Issued February 16, 1909.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 341.

THE BASKET WILLOW.

BY

WILLIAM F. HUBBARD,
Forest Assistant, Forest Service.

WITH A SUMMARY BY C. D. MELL, ASSISTANT DENDROLOGIST, FOREST SERVICE.

1862 1889

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Forest Service,
Washington, D. C., November 17, 1908.

Sir: I have the honor to transmit herewith a manuscript entitled "The Basket Willow," by William F. Hubbard, Forest Assistant, Forest Service, and to recommend its publication as a Farmers' Bulletin. This paper is a condensation and revision of Bulletin 46 of the Forest Service.

Very respectfully,
Gifford Pinchot,
Forester.

Hon. James Wilson,
Secretary of Agriculture.

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THE BASKET WILLOW.

INTRODUCTION.

The cultivation of the basket willow began very early. Among the ancient Romans the shoots were used for the manufacture of beehives and baskets, for garden and vineyard fences, and for binding grapevines, and the wood, covered with hide and bossed with brass, was made into shields, for which purpose its elasticity and lightness peculiarly fitted it. During the middle ages willows were commonly used for basket ware, and in France, and later in Germany, the basket makers' guilds were of considerable importance. During the seventeenth and eighteenth centuries, however, the industry languished.

At the present time France, Italy, the islands of Sicily and Madeira, Belgium, Holland, Germany, Austria, and Russia are all large growers of willow, and have a good export trade of willow rods and basket ware. In all these thickly peopled countries, which abound in cheap labor, willow growing and basket making have followed the development of other manufactures to a very marked degree. In the United States the conditions are altogether different from those on the continent of Europe. Here raw material is cheap in comparison with the cost of labor, and nearly every branch of manufacture tends to concentrate in large establishments with a great number of labor-saving devices. Such an industrial condition has relegated basket making to a very small position in the general world of manufacture. Yet a comparatively small part of our population is made up of highly paid skilled laborers; the great bulk of the people is scattered in the agricultural districts, doing more or less independent hand labor. It has been observed in all countries that willow growing gives an uncommonly high margin of profit. A large demand for willow is now supplied by import, and as American-grown rods are of good quality when proper care is taken in their culture, there is no reason why the further development of the industry should not be possible, if more American farmers can be convinced of its practicability.

Although the last census shows a great falling off since 1899, as does the import of both rods and basket ware, the manufacture of willow furniture, which is lost in the total figures, shows a most promising condition when separately considered. Of late years willow furniture has sprung into fashion, and to-day no minor industry is more prosperous than that devoted to its supply. The wages are good, and the manufacturers demand a steady supply of superior willow. This is now almost entirely received from France at a price which will give the entire trade to the American if he can equal the quality. In basket ware proper the decline seems to have reached bed rock. Experience has proved that no stock is equal to willow when durable baskets are demanded. The high-class basket has made a place for itself in the market even under present circumstances, and the entire decline in the trade has been in the low-priced basket, which competes with the foreign willow product or the American-made wooden basket. To put a low-priced basket on the market with raw willow at its present price the wages must be cut lower than the normal standard in America. For this reason the trade is almost entirely in the hands of immigrant basket makers, who know no other trade and who are seldom or never reenforced by native workmen.

The remedy lies in a reduction in the cost of the raw material. The cheaper the willow (when good in quality) the better the wages which can be paid to produce a low-priced basket, and a low-priced basket of good quality will find an almost unlimited market. On this point the entire trade agrees.

Thus the problem has but one solution. A good grade of willow must be produced at a low cost. To do this, better and more scientific methods must be introduced. At present the willow is grown in the rudest manner possible, and several inferior varieties are planted. The following pages will show how the yield per acre may be increased and the quality of stock bettered. The price will then fall, but with a corresponding gain to the grower in the lessened cost of production. On this depends the future success of basket making in America. An incentive to improvement should be the fact that even under present conditions the American willow tends to displace the foreign in the home market.

DISTRIBUTION AND CHARACTERISTICS OF THE WILLOW.

DISTRIBUTION.

Willows are adapted to a wide range of soils and climatic conditions, and are therefore among the most widely distributed of trees and shrubs. The genus Salix, to which these plants belong, contains a large number of species, ranging from large trees to a small, low plant. From 160 to 170 species are known, inhabiting all regions from the log wounds and river banks of temperate climates and warm countries to the arid Alpine slopes of mountains and to the boreal regions of both hemispheres.[a] They occur in America from the

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[a] There are at least 92 varieties, hybrids, and crosses of the basket willow enumerated in the dealers' catalogues.

Arctic Circle to the West Indies and the mountains of Chile. In the Old World they range from northern Europe and Asia to Madagascar and South Africa, and to the islands of Java and Sumatra.

True to the characteristics of the genus, the basket willow also has a wide distribution over varying climatic conditions. In Europe *Salix viminalis, amygdalina, purpurea,* etc., are successfully grown from Russia, Sweden, and Norway far down into Italy and the Mediterranean islands. In America it is difficult to decide positively just how far the commercial range of the European basket willow coincides with the boundaries within which it is at present grown. How far willow growing can be extended in this country may be found only by actual experience; yet there is every reason to believe that suitable places for willow growing exist throughout the entire United States. There is continual record of small imports of willow from the West Indian islands; and it is quite certain that northern willows suffer quite as much from insect pests as those on the southern boundary of the present willow-growing section. For these reasons it would seem that the South has a good future for this industry if favorable positions are sought for the holts. On the Pacific coast also the high transportation rates which must be paid for the foreign or eastern article should give willow growing a chance to become an economic industry. A start has already been made in California.

CHARACTERISTICS.

In a genus with such a wide range it is but natural that the wood should answer many needs. Both in Europe and to a lesser degree in America the wood is used for many purposes. In this report, however, only the basket willow will be considered.

Although the willow is one of the most widespread and accommodating of plants, and shows such an endless variety of strains, the varieties used in basket making will by no means flourish commercially on all kinds of soil. It is a mistaken idea, however, that it will thrive only on marshy land, though it is true that a fresh soil is needed. That the willow is nevertheless characteristically found in wet places when growing wild is due less to its demands than to its adaptability. It has a poor height growth, and being also intolerant of shade, finds its only chance for life in its capacity for soil adaptation. It is not at all sensitive to moisture, and hence is forced to grow on river banks and lowlands. This is further necessitated by the fact that its seeds can not sprout save on soft, open soil which is free of weeds, and lose their powers of germination in a few days. Such seeds, when left to nature's conditions, find their most favorable bed on the soft alluvial deposits of river banks.

When grown as an article of commerce, the willow is removed from all natural competition, and therefore should be put in a position suited for its development. Both European and American experience have shown that rods grown on moist, rich, well-drained bottomland are more flexible, tougher, and less branchy than those grown on undrained marsh land. This does not mean that valuable fields should be given over to the willow. The most exacting of trees is far less sensitive to soil conditions than any farm crop, and willows thrive on soil which produces even a very poor quality of grass. But the fact remains that the swamp is not the favorite home of the basket willow, and, if a high grade of osier rod is wanted, land permanently saturated with water should be avoided. Ground which is often overflowed grows willow of a high quality, but it must be well drained.

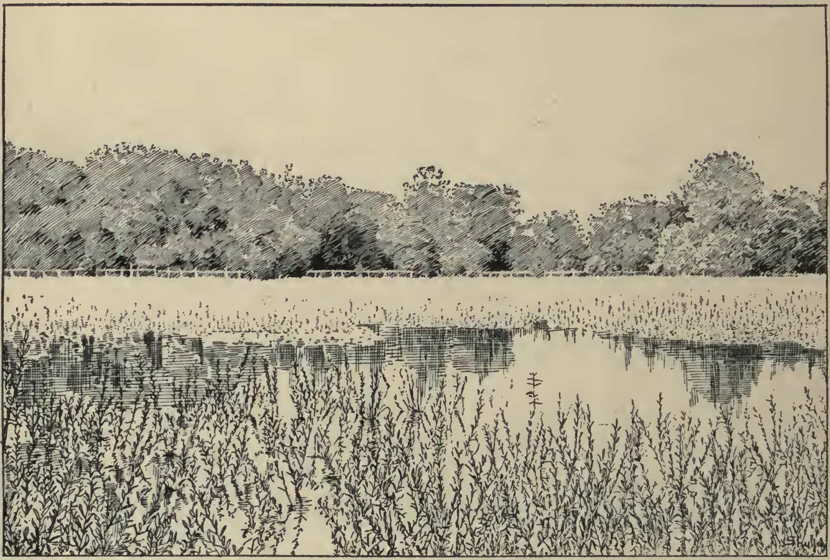

FIG. 1.—Purple or Welsh willow (*Salix purpurea*), part of which has been killed by standing water. New York, July, 1902.

Long-continued inundation is fatal to all species (fig. 1). Nor should its excessive intolerance of shade be forgotten. Weeds and undergrowth of any kind prevent its luxuriant development.

THE PRESENT CULTURE OF WILLOWS IN AMERICA.

Although introduced by German immigrants in the period between 1840 and 1850, willow growing in America occurs only in restricted localities throughout a relatively small portion of the country. Because the growers are thus isolated into small groups with little or no connection, and because these growers are very seldom in touch with the basket makers, there has been little chance for general improvement. It is true that in western New York basket maker and grower are in close communication, but there the trade demands only the cheapest grade of the steamed willow—a condition which, far from being an advantage to the grower, has been his greatest handicap.

Because of these conditions, and, further, because the system of culture, like American agriculture in general, has lacked intensiveness, little or no advance has been made on the method introduced sixty years or more ago.

POSITION OF THE HOLT, OR WILLOW PLANTATION.

Although the idea is common that willows grow only on swampy ground, it takes but little experience to explode this fallacy (fig. 1).

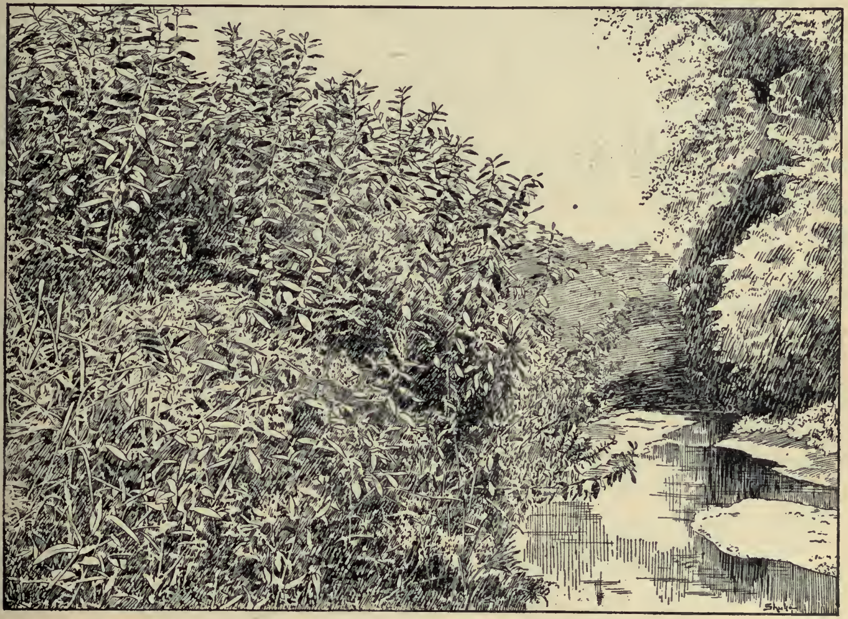

FIG. 2.—Almond or American green willow (*Salix amygdalina*) on well-drained bottomland; rods 7 to 8 feet high. Maryland, September, 1902.

Hence all serious attempts at willow culture are made on well-drained soil, even though it be of poor quality. In many places willows are grown on ordinary corn land, but generally they are planted in low-lying fields subject to occasional inundation (figs. 2, 3, 4, and 5), or in the swales and low places of grain fields, subject to the overflow or drainage of sudden rain storms. When planted on high ground the land chosen is deep and heavy, but when the holt (or willow bed) is subject to inundation the land may be of poorer quality.

PRELIMINARY CULTIVATION.

In most parts of the country the ground is prepared for willows exactly as it would be for corn or wheat. The work is generally done in the preceding autumn, occasionally in the spring. Often where the willows are to be planted on waste bottomland subject to inundation the wild growth is simply cut down and burned on the field and the willows are planted either with preliminary cultivation or in the raw soil.

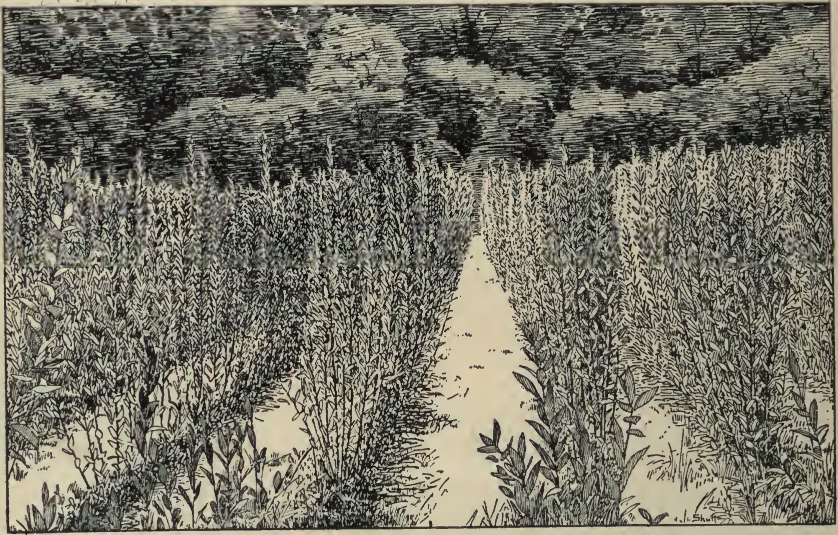

FIG. 3.—Purple or Welsh willow (*Salix purpurea*) planted 3 feet by 1 foot. Maryland, September, 1902.

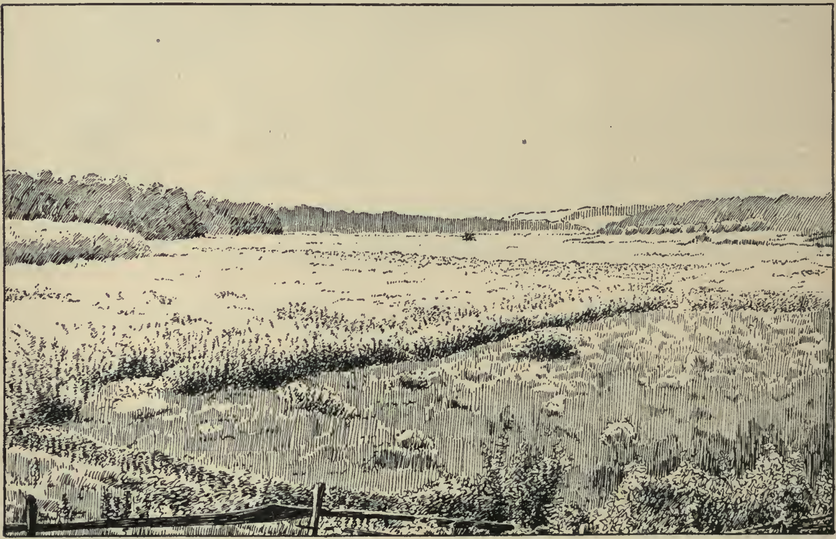

FIG. 4.—Typical willow bottomland. Maryland.

PLANTING.

Almost without exception throughout the country willows are planted from 9 inches to a foot apart, in rows 2½ feet to a yard distant from one another, or from about 14,000 to 23,000 per acre. Here and there occasional growers plant in closer order—even 18 by 8 inches[a]—but they are the decided exception. This method of wide planting is followed for several reasons. It is undoubtedly cheaper to plant fewer cuttings, and the cost of cultivation is much reduced, as a plow may be run through the wide rows. It is also a generally held opinion that the more shoots from a stool (or stump) the greater the yield. Finally, the practice is continued because those who introduced the industry planted in this manner.

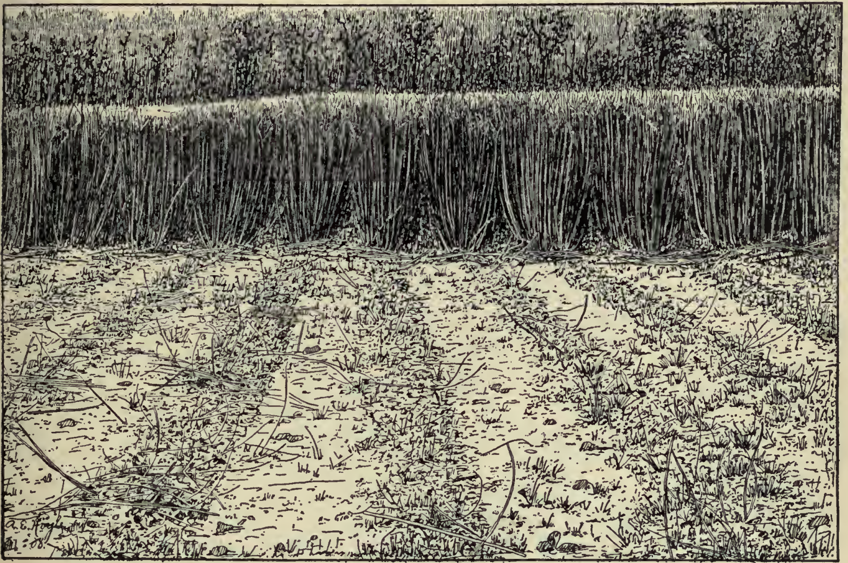

FIG. 5.—Willows on drained land; cut and subsequently inundated. Maryland, March, 1903.

The sets (or cuttings) are cut from one-year shoots into sections about 10 inches to a foot in length and are generally planted with about an inch and a half out of the ground.

WEEDING AND CULTIVATION.

The care of a holt depends so much on the character of the ground that two systems must be separately discussed.

Willows on meadow or corn land.—In the first year the rows are hoed about three times and later run through occasionally with a light plow or cultivator. In subsequent years only the plow is used, several times in the season.

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[a] For results from close spacing see Forest Service Circular 148, "Practical Results in Basket Willow Culture."

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U5 ace.

Willows on bottomland.—In the first year these are sometimes cultivated once, but as a general thing they are only thoroughly grassed with a sickle. This is done twice in the first season and subsequently but once. As the land is inundated every spring, a heavy coat of mud is deposited, therefore no fertilizing and but little cultivation is necessary (fig. 5). This advantage, however, is partially offset by the stimulated growth of weeds, which are very difficult to keep suppressed.

CUTTING.

Unless the holt has been very well tended, the first-year rods may be of little value. They are, nevertheless, cut. As a general rule, however, they are not cut very close, and the projecting head of the set is allowed to stay (fig. 6). This makes the stool branchy and knotty from the first—a very serious fault. In the second year the rods of a carefully cultivated holt should have at least half the value of a full crop and from the second or third year the holt should yield at least twelve good, paying crops. Only a few growers realize the value of an occasional rest. As a rule the holt is cut annually until exhausted. Where steam peeling is practiced, the willows are generally cut as soon as the leaves have fallen in November, so that they may be stripped in the winter. In districts where sap peeling is common the rods are allowed to stand on the stump until March,

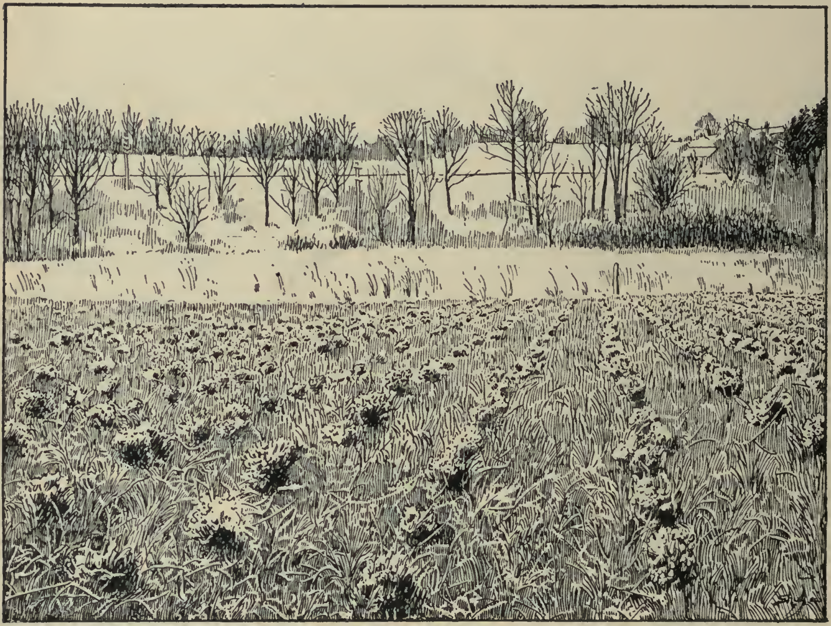


FIG. 6.—Effect of undrained land. Maryland, March, 1903.

when they are cut and immediately drafted (fig. 7), tied into bundles, and put into the pit (fig. 8).

By letting the willows stand all winter and cutting them early in the spring, any trouble in housing the rods is saved. In some districts, however, it is customary to wait until the sap begins to run. This is most objectionable, as the stools bleed and lose vitality.

The cutting is generally done with a knife somewhat similar to that shown in figure 9. In almost every district the value of low cutting is fully appreciated, but the work is seldom carefully done in this respect, mainly because of the added expense.

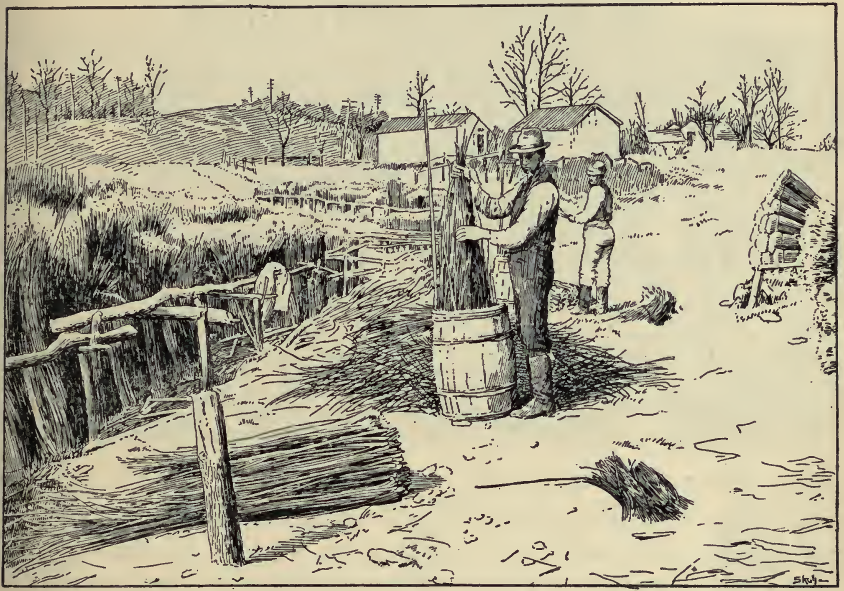
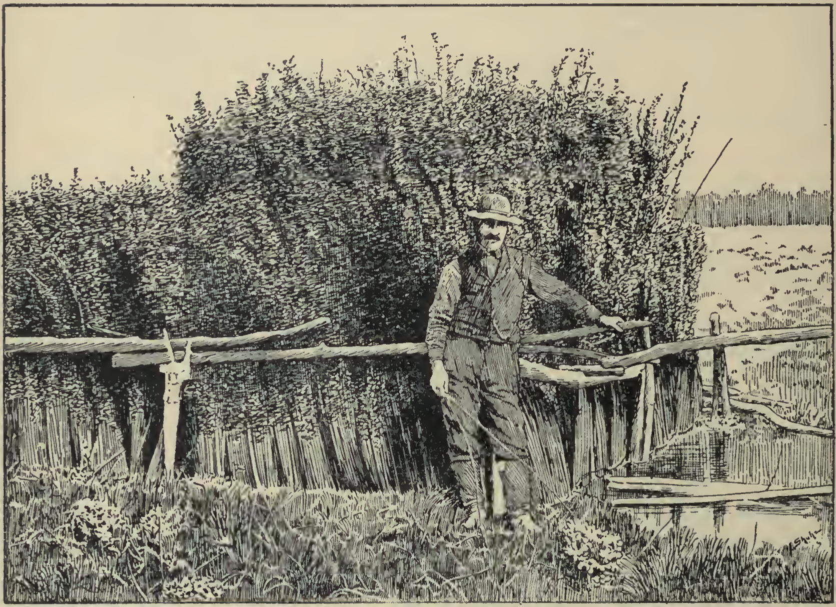


FIG. 7.—Drafting (sorting) willows.

DRAFTING AND PEELING.

After cutting, the rods are immediately sorted into four sizes and bundled. This is called drafting, and is most conveniently done in the manner shown in figure 7. An armful of rods is put into a barrel and sorted according to size with a measuring stick. All rods below A go into the smallest size, those between A and B into the next, those between B and C into the next, and all over C into the largest size. About 40 pounds are put into a bundle, which is firmly bound and taken immediately to the pit (fig. 8). This pit is a series of shallow ponds of water, not over 4 inches deep, in which the bundles are stood. Racks are arranged at regular intervals to keep the bundles upright and secure, but they should not be too closely packed. After the willows have stood in the water for two or three weeks the rods become almost entirely covered with tender, green foliage, while the submerged end is a mass of rootlets. In this condition they are ready for the peeling, which should begin at once. Peeling is done by a man and two strippers, the latter being either boys or women. The brake used for removing the bark (fig. 10, Nos. 4, 5, 6, and 7) is inserted in a beam at a convenient height and the rod passed through it, first in one direction and then in the reverse (fig. 11). This loosens the bark; the strippers then peel it off, either with the fingers or with a dogwood or metallic hand brake (fig. 10, Nos. 1, 2, and 3) and carry the rods to the drying racks (fig. 12), where they are laid in the sun to dry, care being taken to keep the rods in the four sizes arranged in the drafting. After they are sufficiently dry they are tightly bundled by a machine (fig. 13), and in this form shipped to the manufacturer. The machine here illustrated is not in common use, but from its simplicity and efficiency should be more generally introduced. It can be made by hand on the place with the aid of a blacksmith. The main feature is the binding strap, which is so crossed on the axle that by turning the latter the pressure is exerted on the rods not only from the top, but also from the sides and underneath. A cog and ratchet



. FIG. 8.—Willows in the pit, sprouted and ready for peeling.

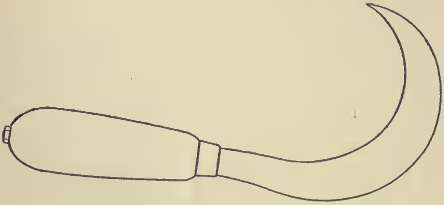


FIG. 9.—Knife for cutting rods.

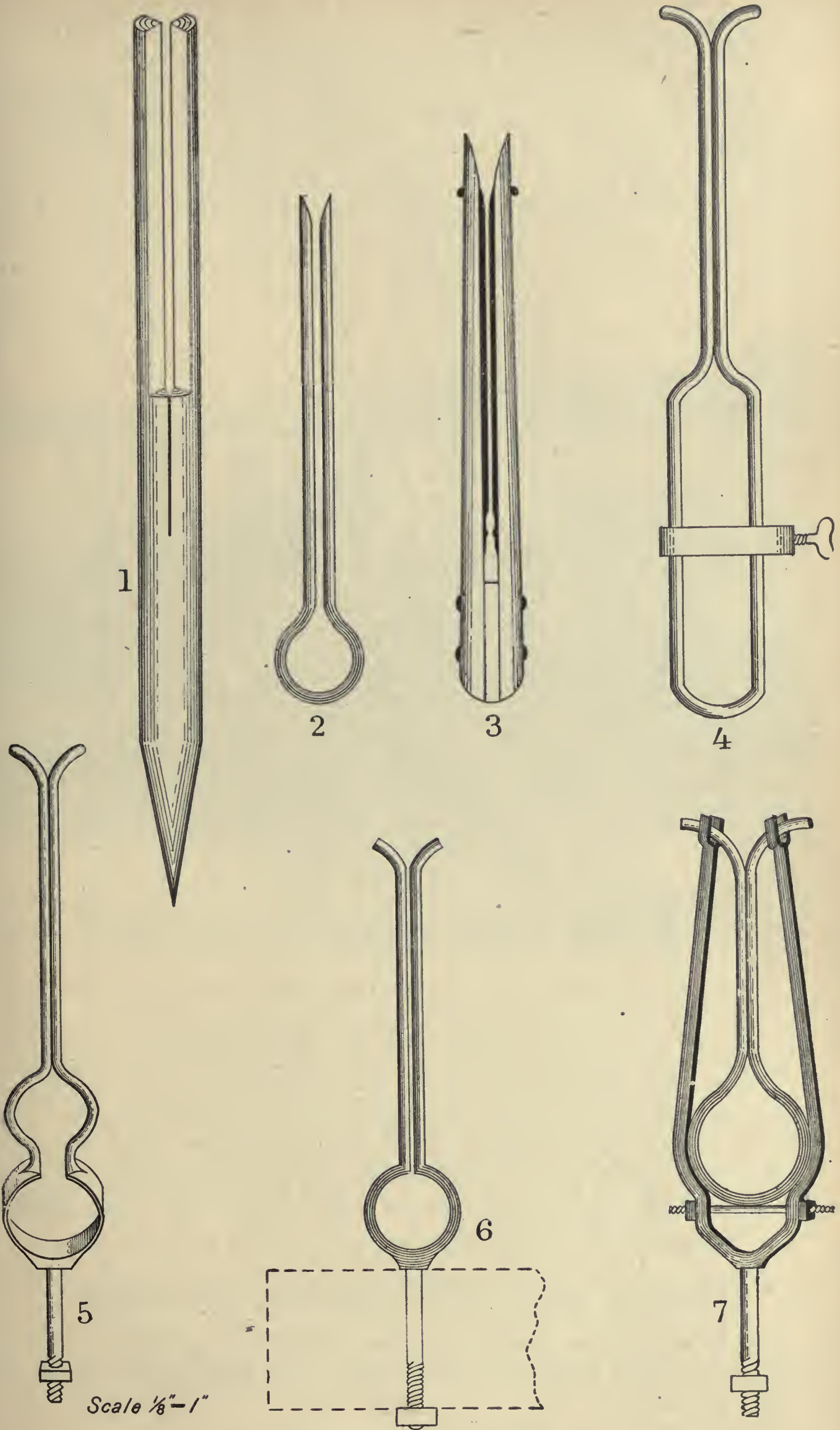


FIG. 10.—Seven types of brake.

attachment on the axle holds the tension while the bundle is being tied; the necessary cord is held in a reel under the machine.

It does not pay to peel the smallest size of rods with the rest, so they are generally put out to families to peel at a given rate per pound, women and children doing the work. The grower makes little or no profit on these rods, but the basket-maker's demand for a certain amount of small stuff makes it necessary to have such stock on hand.

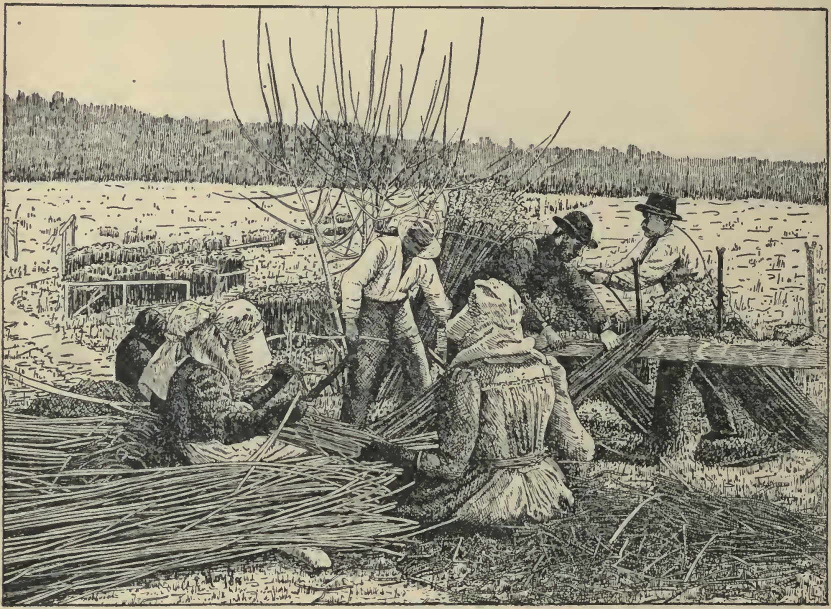


FIG. 11.—Peeling willows in the sap.

SUGGESTED IMPROVEMENTS IN CULTURE.

The following suggestions concerning willow culture in America have been prepared after a careful study on the ground of actual conditions both here and in Europe. While the introduction of any new system in a particular locality calls for a consideration of questions of labor, market transportation, etc., all of which can not be taken into account in a general discussion, there is room for many improvements on present methods, and the intelligent application by the individual grower of the information here given should enable him in most cases decidedly to increase his profits.

CHOICE OF LAND AND PRELIMINARY CULTIVATION.

Any extra expense incurred in the preliminary cultivation of the soil will be repaid in the increased yield. The land should be plowed and harrowed exactly as for any field crop, and should be fertilized with lime or wood ashes if calcareous constituents are lacking. Even fields subject to inundation should be well cultivated before planting.

If the holt is to be planted on land which is never flooded, the soil should be deep and moist, but not necessarily rich. If the land is subject to inundation in the spring, it should be thoroughly drained. Not only are the rods brittle and of poor quality on swampy soil, but the winter frost forces the stools out of the ground, making large heads above the surface and neutralizing the effect of good cutting (fig. 6).

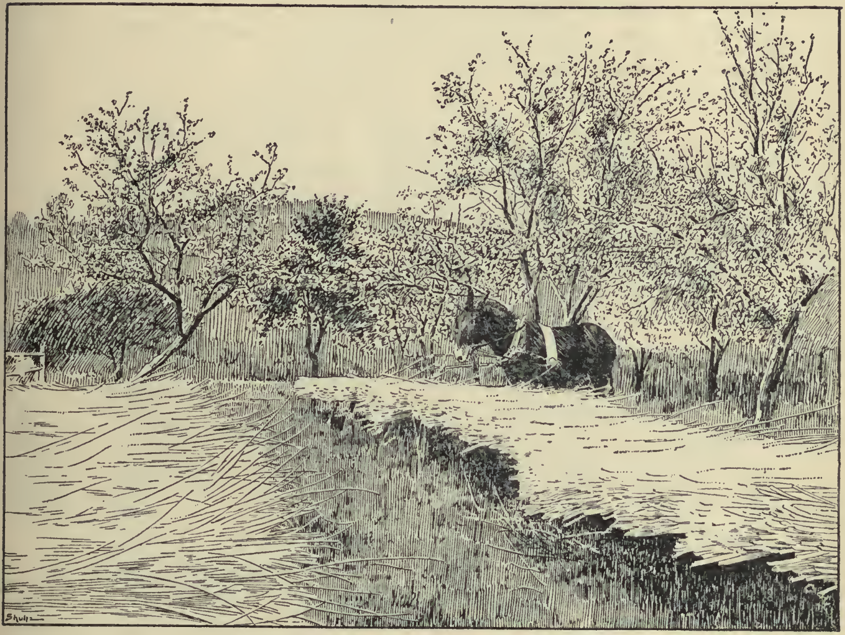


Fig. 12.—Drying the peeled rods on the racks.

There is no doubt that land subject to inundation is the best for willow growing. If it can be perfectly drained and the flooding regulated, ideal conditions are present for the production of high-grade stock. The flooding does away with any need for fertilizer, and the layer of deposit keeps the stools well covered (fig. 5), while if the water stands long enough, the larvæ of insects are likely to be killed. All these advantages counteract the additional danger from weeds, which can be kept under if attacked early enough in the season. In a suitable location flooding can be inexpensively provided for by the construction of a weir dam. This would easily pay for itself in the facility with which the water could be regulated. Figure 14 shows a good location for willow growing on inundated land.

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By planting from 34,000 to 81,000 sets per acre, or at distances from 20 by 9 inches to 16 by 6 inches, both a much heavier yield and longer, more even-sized, and better rods are obtained—straighter, less branchy, and less tapering.[a] (Fig. 15.) The main objections to close planting are the increased initial cost, the greater amount of cultivation necessary, and the more rapid exhaustion of the holt. But the average yield from a holt planted 3 feet by 1 foot after the second year is 4 tons green per acre for about twelve years, while that from an acre planted 20 by 9 inches should not be less than 6 tons green for ten years. This gives the close-planted holt an excess yield of 12 tons over the one planted 3 feet by 1 foot, to say nothing of the extra yield in the first and second years. In Tables I and II the expenditure and return under both systems of planting are given in detail. (See pp. 28, 30.)

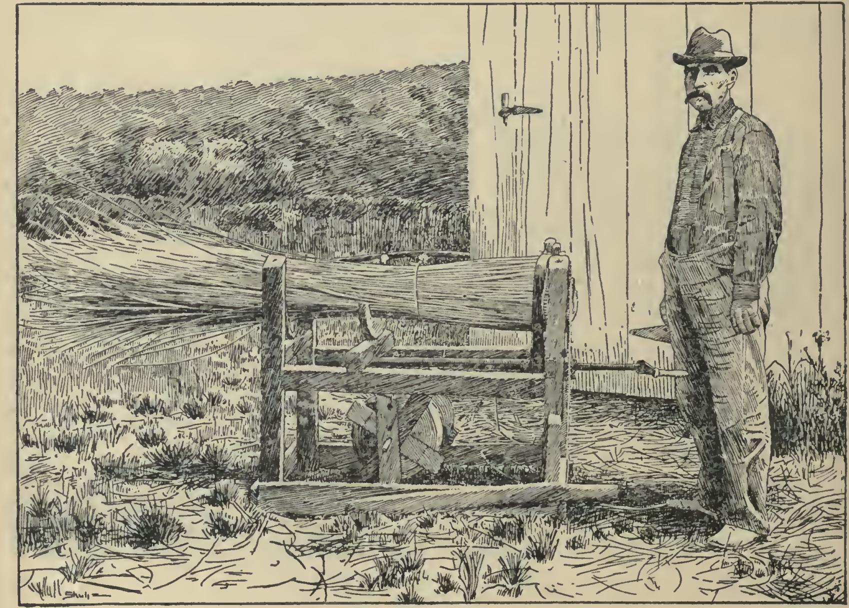

FIG. 13.—Machine for bundling willows for market.

These estimates, however, take no account either of the improved quality of the entire crop or of interest on the larger profits secured. With these reckoned in, a much larger balance in favor of close planting would be obtained.

Of course the conditions which determine the application of different methods of willow growing are purely local, and the price of labor and the market for the stock must fix the method of culture,

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[a] See Forest Service Circular 148.

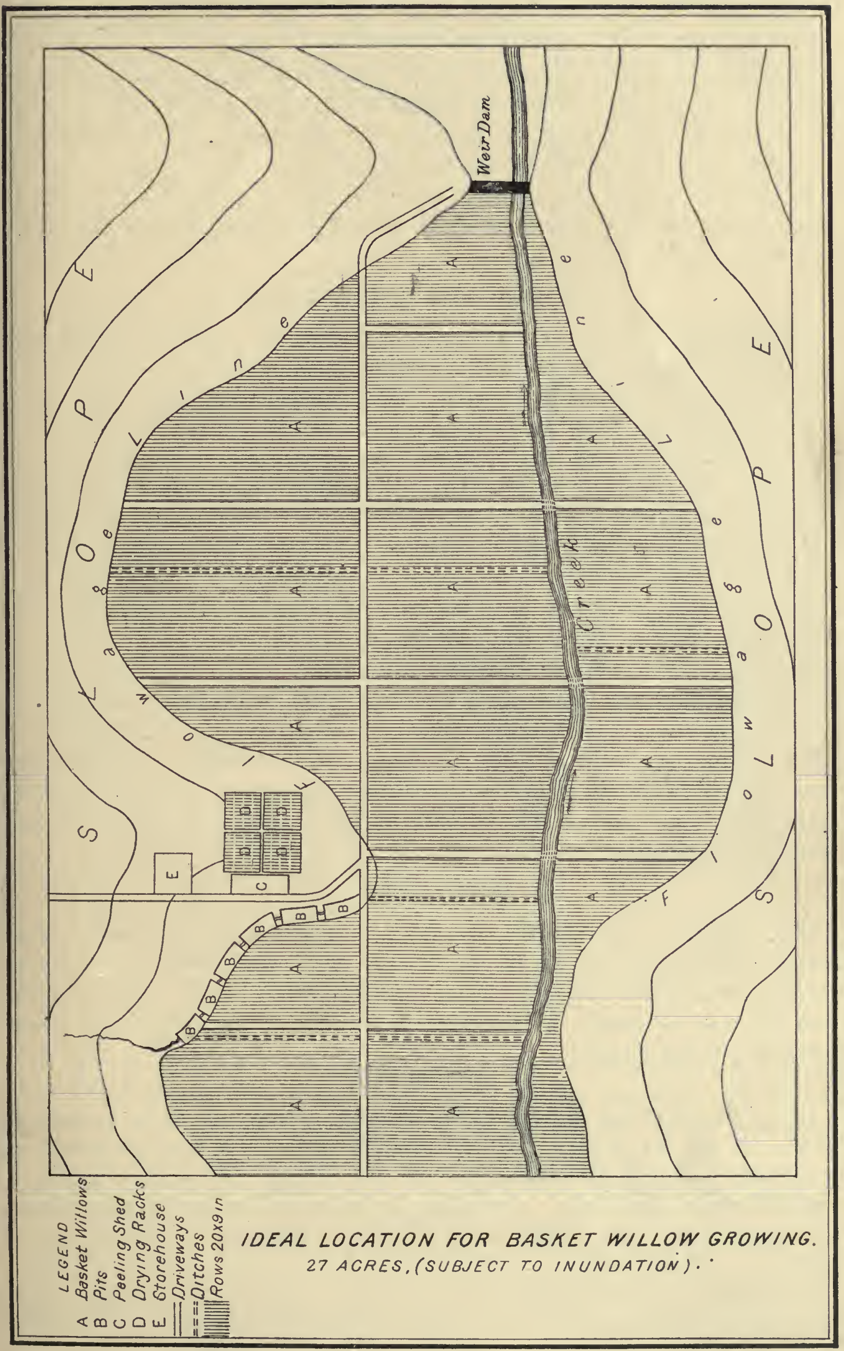

FIG. 14.—Ideal location for basket willow growing.

but if labor can be obtained and the market is thoroughly known, a willow holt will pay as much as any field crop, and possibly more. While in many instances it would not be advisable to change the present method of cultivation, there are places where close planting and careful cultivation would undoubtedly pay handsome returns. For American conditions, 20 by 9 inches, giving about 34,000 plants per acre, would probably be the best distance. Care should be taken that the sets are 12 inches long and planted with the buds pointing upward, and that they are pushed into the ground perpendicularly to within 1 inch of the top.

WEEDING AND CULTIVATION.

When willows are close planted it is absolutely essential that weeds and grass, under all circumstances their arch foes, should be kept out during the early life of the holt. Afterwards, when the stools have become vigorous, they are able from their close rank to shade out other plants if the first cultivation in the spring has given the weeds a setback. But in the first year the cultivation should be so thorough that the weeds may get no chance to develop. In normal years three or four hoeings should suffice for this. Two hoeings should be given the second year. After that time one hoeing should be sufficient. The first cultivation should take place very early in the spring, before the stools have begun to sprout, and the soil should be heaped up over the plants. If the ground has been inundated after cutting, the stools will be sufficiently covered, and the first cultivation may be deferred until the weeds begin to start.

Two thorough hoeings under normal circumstances will be found to cost little more than ordinary grassings or other methods of cultivation in vogue, and it is but little more trouble to hoe an acre set with 34,000 plants than one with 14,000.

FERTILIZING.

On ordinary soil willows should be fertilized every four or five years, beginning with the fifth or sixth. This makes two treatments during the normal life of a close-planted holt. Any ordinary field manure may be used. If the land is flooded in the spring, no other fertilizing is necessary.

INSECTS.

In combating the danger from insects, a first requisite is united action by all the growers of one neighborhood. A few uncared-for holts will completely neutralize all the efforts of careful growers. Against the ravages of such insects as the cottonwood leaf-beetle or caterpillars, spraying with poison is generally efficacious if commenced early enough in the season.

One of the most terrible willow scourges is the willow-shoot sawfly. For this a good remedy is to cut the willows entirely off immediately after the fly has made its appearance, and to be effective this must be done throughout the whole region, even at the sacrifice of a year's crop.

For information in regard to insects affecting the basket willow and methods for their control, application should be made to the Bureau of Entomology of this Department, and it will greatly facilitate correspondence if specimens of the insects accompany letters of complaint or inquiry.

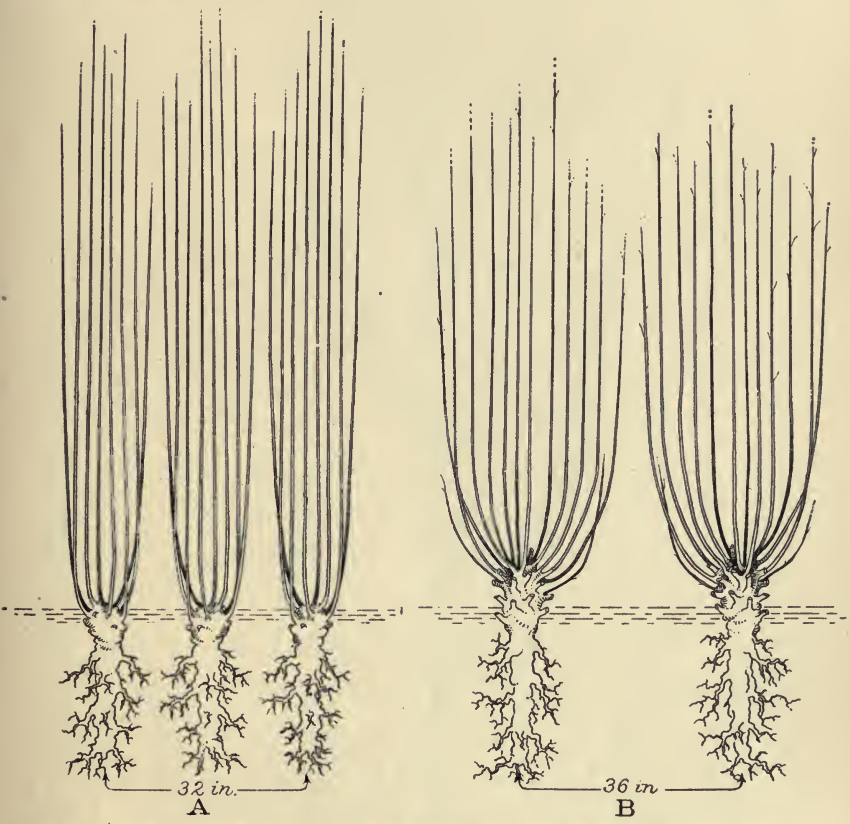

FIG. 15.—Comparison of close planting and good cutting with wide planting and careless cutting.

CUTTING.

When the rods are to be steamed, they may be cut any time during the period of rest, but when they are to be sap peeled it saves storage to let them stand on the stools until the spring. Care, however, should be taken to cut them before the sap begins to move.

The necessity for close cutting can not be too much emphasized. The rods should be taken off as close as possible to the stool.[a] Figure 15 shows the difference between good and bad cutting. A illustrates the growth of the rods from a low-cut, compact stool, and B that from a high-branching one.[b]

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[a] For the results from later experiments in cutting see Forest Service Circular 148.

[b] Figure 15 is taken from actual examples.

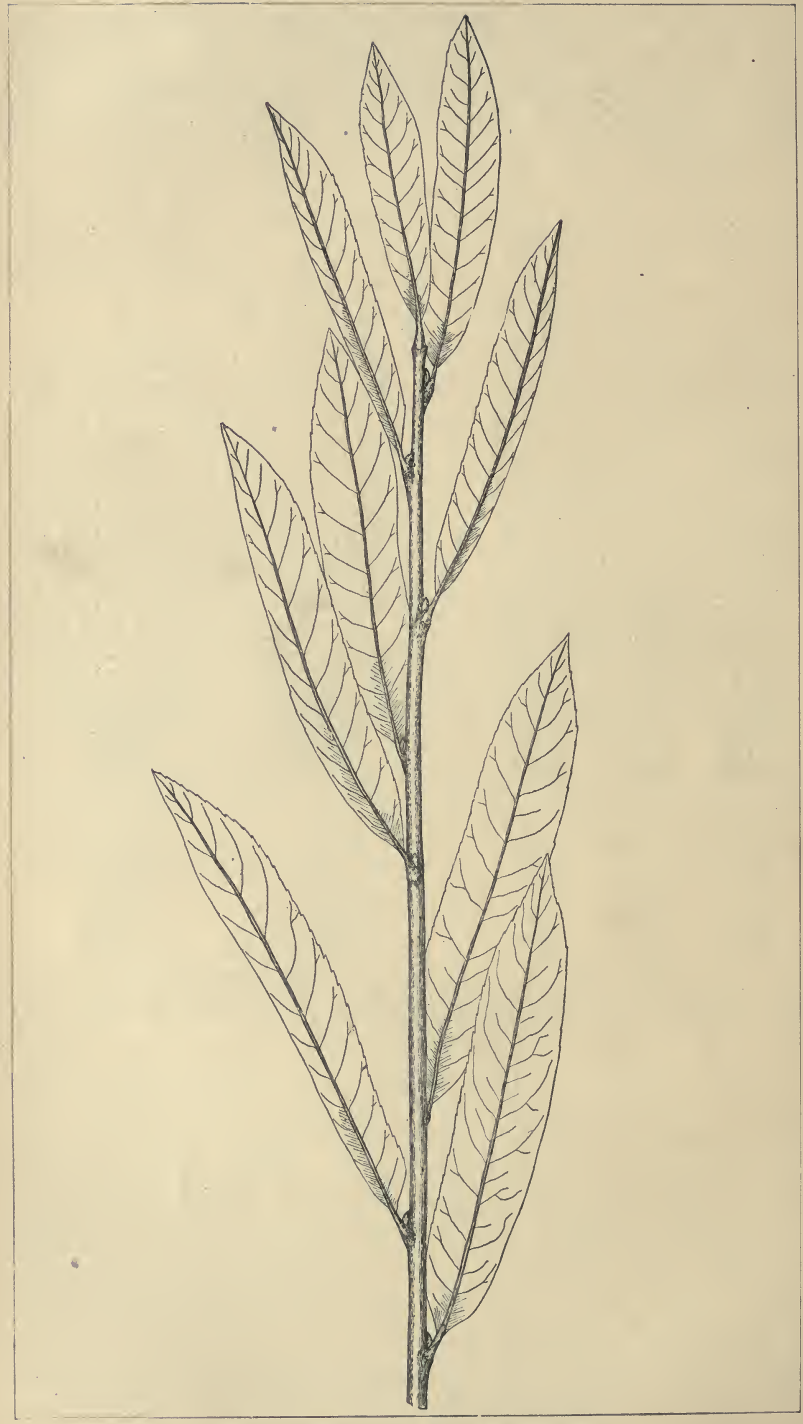

FIG. 16.—Welsh or purple willow (⅘ natural size).

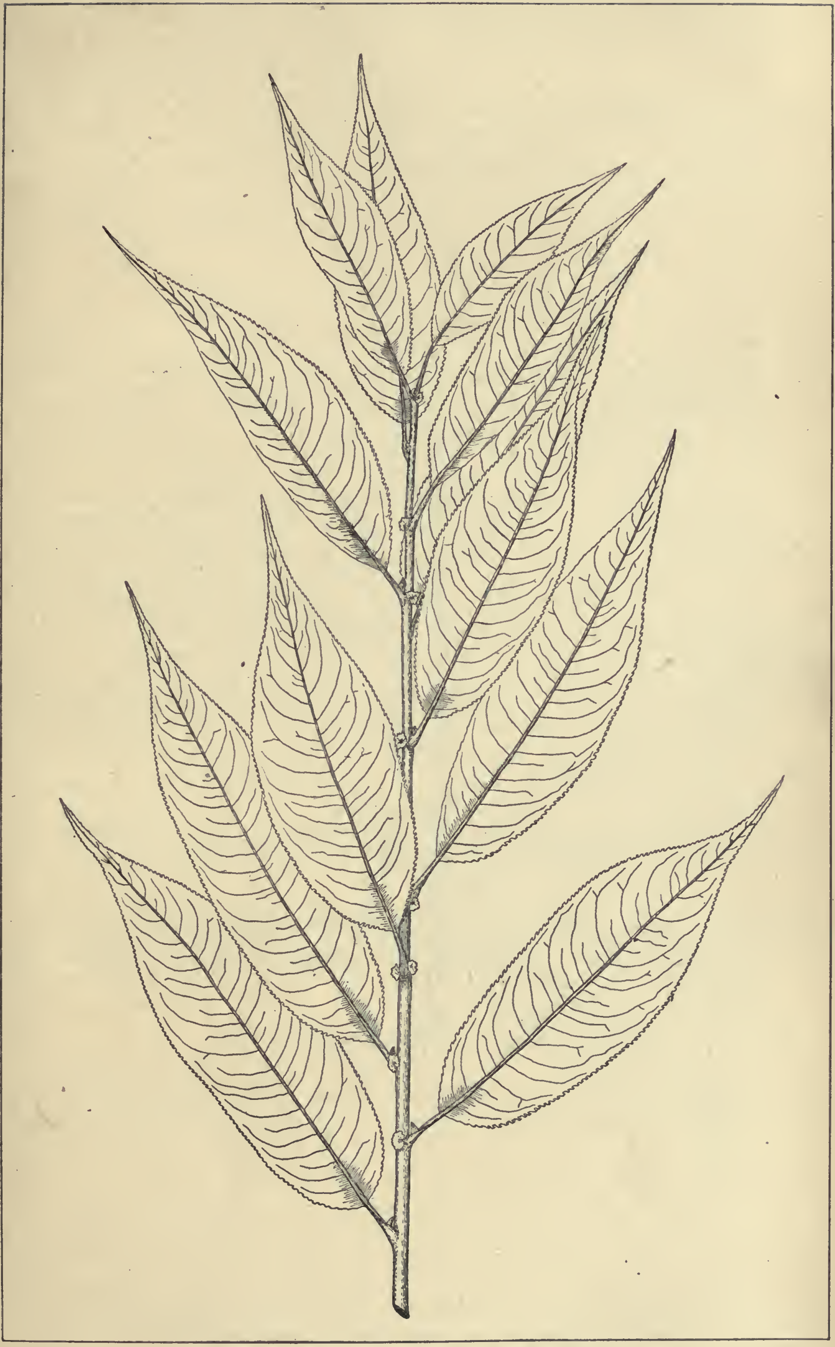

FIG. 17.—Lemley or Caspian willow ($\frac{3}{5}$ natural size).

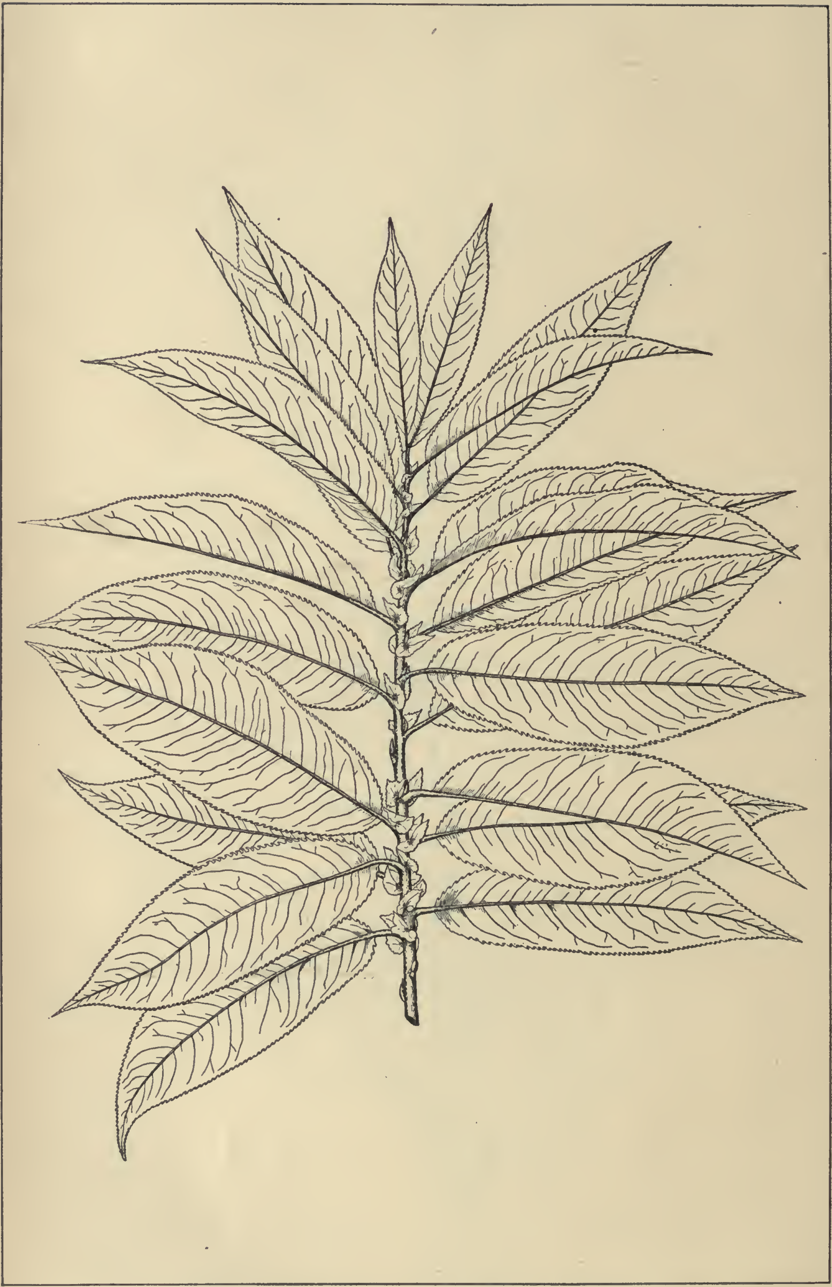

FIG. 18.—American green or almond willow (⅓ natural size).

After the rods have been cut it is well to go over the holt and thoroughly clean the stools, removing all rods that may have been left. If the holt can be flooded, the water should be let in, covering the stools with a coat of mud.

One of the most successful ways of increasing the holt's vitality is to let the rods stand occasionally for two years. The sixth and the tenth years are good ones for leaving the holt uncut. Many growers think that such a rest makes the subsequent crops brittle, but there is nothing to substantiate such a theory.

PEELING, SORTING, PACKING, ETC.

The present system of drafting and peeling can not be much improved, but greater care should be taken in sorting. Almost all basket makers complain of the irregularity of American willow. At present the rods are put into four sizes before they are peeled, and are not sorted after they are white. A second drafting when they are put on the drying racks would be no difficult matter, and would undoubtedly pay. The loss of weight in the hands of the manufacturers comes from too early shipment after peeling, and under present conditions is difficult to remedy. Anything which will make his rods of superior quality should be attempted by the grower. It is to his advantage to have his customers know him for his reliability and the superiority of his stock. If he can establish himself in a sufficiently close relation with them to enable him to work with them for the supply of such rods as are likely to be most in demand, so much the better for grower and consumer alike.

EXPENDITURE AND RETURNS IN AMERICAN WILLOW CULTURE.

In estimating the expenditure in willow growing, the holts on farm land and those on bottomland subject to inundation should be considered separately.

WILLOWS GROWN ON UPLAND.

In Table I the present and estimated expenditures and returns are given for willows on upland.

TABLE I.—*Willow culture on upland.*

	A.—Steam-peeled rods as grown in New York.			B.—Steam-peeled rods to be grown 20 by 9 inches apart.			C.—Sap-peeled rods to be grown 20 by 9 inches apart.		
	First year.	Second year.	Third to fourteenth years.	First year.	Second year.	Third to twelfth years.	First year.	Second year.	Third to twelfth years.
Annual expenses per acre.									
Preparation of land	$10.00	....	....	$10.00	....	....	$10.00	....	....
Sets	[a] 14.00	....	....	[a] 35.00	....	....	[b] 105.00	....	....
Planting	4.50	....	....	12.00	....	....	12.00	....	....
Plowings, at $1 each	2.00	$2.00	$2.00	....	....	....	....	....	....
Hoeings, at $4 each	8.00	8.00	....	16.00	$12.00	$8.00	16.00	$8.00	$4.00
Spraying	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Cutting:									
Salable rods, at $5 per ton	5.00	10.00	20.00	7.50	20.00	30.00	10.00	20.00	30.00
Left-over rods	1.00	1.00	1.50	1.00	1.00	1.50	1.00	1.00	1.50
Drafting, at $3 per ton	....	....	....	....	....	....	6.00	12.00	18.00
Peeling, at $10 per ton	....	....	....	....	....	....	20.00	40.00	60.00
Total	48.50	25.00	27.50	85.50	37.00	43.50	184.00	85.00	117.50
Annual returns per acre.									
Willow:									
Green, at $15 per ton	15.00	30.00	60.00	22.50	60.00	90.00	75.00	150.00	....
White, at 5 cents per pound	....	....	....	....	....	....	....	....	225.00
Gross gain	....	5.00	32.50	....	23.00	46.50	....	65.00	107.50
Gross loss	33.50	....	....	63.00	....	....	109.00	....	....
Amount of net loss of previous year, with interest at 5 per cent	....	35.18	31.69	....	66.15	45.30	....	114.45	51.92
Net gain	....	....	.81	....	....	1.20	....	....	55.58
Net loss	33.50	30.18	....	63.00	43.15	....	109.00	45.25	....

[a] Welsh willow, at $1 per M.

[b] American green, Lemley, and patent Lemley willows, at $3 per M.

Column A is based on the system as practiced in New York State, but should hold good for all regions under like conditions. The sets are supposed to be Welsh willow, and are taken at the usual cost near Lyons, N. Y. While many holts are less highly cultivated, this estimate may be taken as fairly representative of the average expenditures. From the figures it is seen that at the end of the third year the initial expenditure is entirely repaid and a net gain made of $0.81 per acre. A fair holt will average 4 tons of willow per year for twelve years after the second year. From the fourth through the fourteenth years the gain of $32.50 in the third year may be taken as an average, giving a profit of $357.50, or a total profit of $358.31 per acre for the fourteen years of the existence of the holt. In order to find the net profit for the period the following should be deducted:

Rent at $5 per acre for fourteen years at 5 per cent	$97.99
Incidental expenses	10.00
Total	107.99

This leaves $250.32, or an average net profit of $17.88 per acre for fourteen years. This estimate should hold good for all localities where willows are steam peeled.

In order to get a greater yield at a lower price the method as given in column B of Table I is proposed. According to German and English experience holts planted 20 by 9 inches yield an average of 6 tons per acre for at least nine years after the third year. Accordingly there is an average profit of $46.50 per acre (as in the third year), or $418.50 for the period, amounting to $419.70 as a total yield for twelve years. To find the actual profit further expenses must be deducted, as follows:

Rent at $5 per acre for twelve years at 5 per cent	$79.59
Fertilizer	10.00
Incidental expenses	15.00
Total	104.59

This leaves $315.11, or an average of $26.25 per acre for twelve years, as compared with $250.31, or an average of $17.88 per acre for fourteen years, obtained by planting 3 by 1 feet, as at present. A careful study of the items in column B will show that each cost estimate is an extreme figure, while the yields given have been found only a fair average in England and Europe, where many holts give 8 tons per acre as a regular average.

If the grower of willows on upland intends to peel his stock in the sap, he should select American green, Lemley, and patent Lemley as well as Welsh willow. The sets of the first-named varieties cost about $3 per thousand at present. The results under close planting would be as given in column C. At a gain of $107.50 per annum, $967.50 will be realized from the fourth to the twelfth years. Including $55.58, the gain in the third year, a total of $1,023.08 is obtained. The following additional expenses per acre must be deducted:

Rent for twelve years at $5 per acre at 5 per cent	$79.59
Fertilizer	10.00
Incidental expenses	15.00
Total	104.59

There should thus be a net profit per acre of $918.49, or $76.54 per year for twelve years.

WILLOWS GROWN ON LAND SUBJECT TO INUNDATION.

It is a noticeable fact that the best willow raised in this country, and that which commands the highest price, is grown on well-drained bottomland in Pennsylvania and Maryland. The actual methods of culture are, if anything, less intensive than those in other districts; yet the willow is less subject to insect damage, is better grown, and is generally of a finer quality than elsewhere. This is only in small part due to the use of better varieties (American green, Lemley, and patent Lemley); it may be almost wholly ascribed to the fact that the land is subject to overflow in the spring. This acts as fertilizer, and builds up the soil about the stools.

Table II.—*Willow culture on bottomland subject to inundation.*

	A—Sap-peeled rods as grown in Maryland.			B—Sap-peeled rods to be grown 20 by 9 inches apart.		
	First year.	Second year.	Third to fourteenth years.	First year.	Second year.	Third to twelfth years.
Annual expenses per acre.						
Share of $200 dam	....	....	....	$10.00	....	....
Preparation of land	$25.00	....	....	25.00	....	....
Sets	42.00	....	....	105.00	....	....
Planting	5.00	....	....	14.00	....	....
Mowings:						
Grass, at $8 each	16.00	$8.00	$8.00	....	....	....
Vines, at $2 each	2.00	2.00	2.00	2.00	$2.00	$2.00
Hoeings, at $4 each	....	....	....	16.00	8.00	4.00
Cutting:						
Salable rods, at $5 per ton	5.00	12.50	20.00	10.00	20.00	32.50
Left-over rods	1.00	1.00	1.50	1.00	1.00	1.50
Drafting, at $3 per ton	3.00	7.50	12.00	6.00	12.00	19.50
Peeling, at $10 per ton	10.00	25.00	40.00	20.00	40.00	65.00
Total	109.00	56.00	83.50	209.00	83.00	124.50
Annual returns per acre.						
White willow, at 5 cents per pound	37.50	93.75	150.00	75.00	150.00	243.75
Gross gain	....	37.75	66.50	....	67.00	119.25
Gross loss	71.50	....	....	134.00	....	....
Amount of net loss for previous year, with interest at 5 per cent	....	75.08	39.20	....	140.70	77.39
Net gain	....	....	27.30	....	....	41.86
Net loss	71.50	37.33	....	134.00	73.70	....

In Table II, column A shows as accurately as possible the present cost of growing in Maryland. The rent has been taken at the normal price which should be paid for bottomland in brush. It was found in many cases that willow growers were paying for ground otherwise useless a rent which could hardly be obtained for the best truck-gardening sites. Such a state of affairs had come about in consequence of making short leases or renting from year to year. Once the land was cleared and in willows, growers would pay many times what they should rather than change or go out of business. Such conditions should not be considered in a normal expense account. From the present method of growing, a profit of $66.50 is made in the third year, as given in column A. The same will hold good for the next eleven years, giving $731.50 for the period, or a total of $758.80 from the acre. Deducting from this fourteen years' rent, at $3 per acre, amounting at 5 per cent compound interest to $58.80, and $15 for incidental expenses, a net profit of $685 is obtained, or $48.93 per acre per year for the fourteen years of the holt's existence.

The superiority of willows grown on bottomland has been explained as due to the greater uniformity of moisture and the value of the annual deposit of sediment. For this reason the building of a dam to regulate the water supply and drainage is urgently recommended on every willow plantation of any considerable size. In column B the figures are calculated on a basis of 27 acres and the cost of the dam included. Estimating after the manner of the preceding columns, the total return from the acre in twelve years will be $1,115.11. Subtracting $47.75 for rent, at $3 per acre for twelve years, with compound interest at 5 per cent, and $20 for incidentals, there is a net return per acre of $1,047.36, or $87.28 per acre for twelve years.

SYSTEMS OF PEELING COMPARED.

In comparing the two systems of peeling at present in vogue in America, a great difference in returns appears between willows grown for steam and for sap peeling. Practically the entire amount of steam-peeled willow comes from New York. It seems strange that the district which produces nearly half the value of the entire production in America, and three-quarters of the actual amount grown, should resort to a cheap method when other districts get nearly four times as much for their willows. Yet the matter is more simple than it seems. New York is the center of an old industry, where there is no skilled labor, and the willows are steam peeled to help make a cheap product. The product of Maryland and Pennsylvania is sold to the makers of fine baskets and furniture, and competes with the imported French willow. Hence it must not be forgotten that the market for willows grown according to the estimates in Table I is much larger than that for the estimates of Table II. The market for willows which yield at present over $50 an acre is a limited one, and if many growers take up the new system, which is estimated to give a return of $87.28 per acre, they must count on a speedy fall in the price of raw willow. Yet the margin between $87.28 an acre and $50 an acre is amply sufficient to allow a substantial fall in price and still give the grower a better profit than he can now make by the present method of culture. Such a condition is exactly the ideal to be striven for. If fine willows can be raised profitably at 4 cents a pound, there is an import trade of nearly $40,000 to be captured, together with the increase in the basket output which would follow a reduction in price of the raw material. These facts should convince the willow grower that it is to his advantage to take up the new method, and in the increased yield per acre and superior quality of the stock to make a profit greater than that possible by his old method at a lower market price per pound. In practice the advantage of bottom over meadow land would be even greater than shown in Tables II and III. The highland willows must be regularly fertilized and the earth banked about the roots. They are subject to drought and to insect ravages, while those grown on land which is regularly inundated can be kept in better condition. For these reasons the average crop has been set at 6½ tons, a figure which results will certainly justify.

The increase in yield by the new system is proportionately the same for willows intended for sap and for steam peeling, and the choice of methods must depend entirely upon the local market or other conditions.

FIELD EXPERIMENTS OF THE FOREST SERVICE.

In the seasons of 1903 and 1904 experimental plats of basket willows were set out on the Government experimental farm at Arlington, Va. The holt, which at present covers 66 square rods, is situated on rich Potomac bottomland. The American green, patent Lemley, Lemley, and Welsh willows are planted 18 by 6 inches, 20 by 9 inches, and 36 by 12 inches apart. The object of establishing this plantation is to determine the proportionate yield for these willows under different systems of spacing and under similar soil conditions.

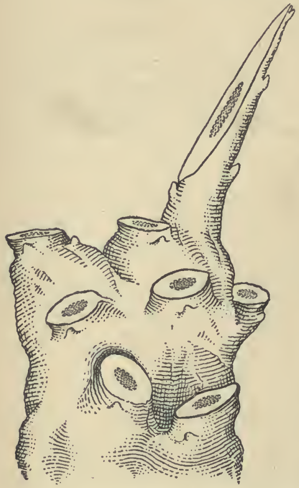

FIG. 19.—Example of good and bad methods of cutting.

A number of new varieties were brought from Europe and planted here during the spring of 1908 for the purpose of increasing the varieties of basket willows suitable for cultivation in this country. Each variety will be planted in several spacings, as above indicated, to determine the effect of close and wide spacing on the yield and on the life of the holt. The effect of low cutting on the yield, character of the rods produced, and vitality of the stools, both in close and wide planting, will also be noted, together with many other important considerations to be included in these experiments. Careful study will be made of the proportion of wood to bark and of the comparative weight of the peeled and dried rods for each species, variety, and strain.

A number of experiments have been completed already and the results published. The results of other experiments will be published from time to time for the benefit of those engaged in basket willow culture.

A part of the willows grown each year is distributed, in the form of cuttings and free of charge, to farmers and others desiring to establish basket willow holts.

WILLOWS FOR GROWING IN AMERICA.

The qualities required to constitute a perfect rod are extreme toughness, elasticity, a level, smooth, and brilliant white surface after peeling, good splitting quality, freedom from branches, great length of shoot in proportion to thickness, and a small pith. The development of a species which will produce such rods and which at the same time is hardy and not liable to ordinary diseases, and a good cropper, is the end for which growers should strive. This demands that the greatest care should be exercised, not only in the choice of species, but also in methods of culture. Good varieties give no results under careless methods; even inferior kinds will pay if well tended. It should be the object of every grower to lower the price and better the quality of his willow, for on this depends the future success of American willow culture. If rods equal to the French and cheaper in price can be put on the market, there will be an opportunity for a great expansion of basket and furniture manufactures, and the growers will more than make up in larger sales what they lose in price per pound.

Of the 92 varieties of willow and hybrids known to European culture, the only ones extensively planted in this country are: The American green or almond willow (*S. amygdalina*), the purple or Welsh willow (*S. purpurea*), and the Caspian or Lemley willow (*S. pruinosa acutifolia*). It is worth while to describe these in some detail.

(1) The almond willow (*Salix amygdalina*, fig. 18) is the most widely cultivated willow in the north of France, and is much used in England and Germany. The growers in Maryland and Pennsylvania also grow it under the name American green. The wood is strong and heavy, so that basket ware made from it is very durable—an important point in competition with rattan. It is also easily bent, tough, and not difficult to split, and its color is a brilliant white. Yet it is just as easily used for coarse work as for fine, and for ''brown'' or unpeeled as for peeled basket ware. Some of the shoots are heavy enough to be used for the heaviest baskets; others are good for fine workmanship. Although the almond willow prefers a heavy land, it does well also on sandy soil. It demands, however, a soil full of nourishment. It has the heaviest foliage of all willows. This great leaf area makes vigorous growth possible, and in the fall covers the earth with litter. Consequently weeds have the least chance to grow, while the heavy shade keeps the ground fresh and unburnt. One of the most serious faults of this willow is a tendency to branch, a peculiarity of certain other varieties in varying degrees, and which may be reduced to a minimum in all cases by close planting. It is also more sensitive to damage by hail than any other willow, wart-like excrescences or black spots forming on the places struck by hail-

stones. It is cultivated in Maryland, Pennsylvania, through Indiana, Ohio, and Kentucky, and as far as Illinois, and everywhere is in high demand, especially for furniture.

(2) *Purple or Welsh willow* (*Salix purpurea*, fig. 16).—This is perhaps the most beautiful of all the willows. It produces a large number of supple, slender, and even-sized shoots, with no tendency to branch. It grows slowly, however, and never attains a great size. The rods are very difficult to peel, and the wood is extremely hard, of a bad color, and not easily split. The ground most suited to its growth is a fresh sandy loam with considerable humus. On heavy land it does poorly. The purple is the hardiest willow known. Cold and heat, wet and excessive drought—all these extremes have less effect on its growth than on any other basket willow. It is also a good cropper; holts have often been cut forty years. It is the most commonly grown willow in America.

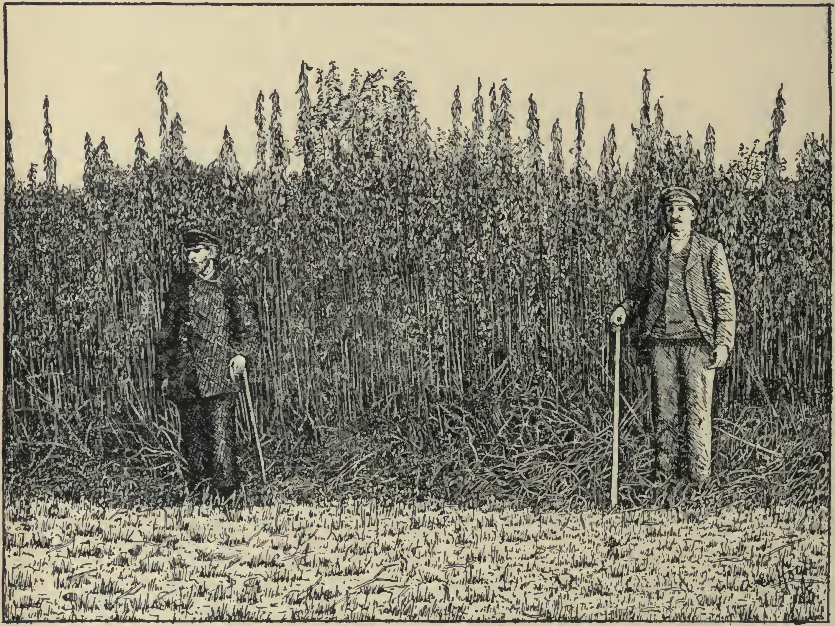

FIG. 20.—First-year rods of common white willow from newly planted sets. Germany, November, 1902.

(5) *Lemley and patent Lemley, or Caspian willow* (*Salix pruinosa acutifolia*, fig. 17, *and variations of the same*).—The Lemley has been much recommended for planting on sandy soil, where it is said to do better than any other willow. It is a serviceable species and gives good rods, which peel well and are white. As it sends out very few rods from a stool and has a tendency to branch, it should be planted in close order. With its hybrid, the patent Lemley, it is common and highly valued in parts of the willow-growing district of America.

MANUFACTURE OF WILLOW WARE IN THE UNITED STATES.

GENERAL REMARKS.

In Europe to-day every grade of basket, from the finest to the coarsest, is made of willow, and of almost nothing else.[a] The heaviest farm baskets and receptacles used for handling rough merchandise are made out of unpeeled willow, and from this its use extends through all the grades of basket ware—peeled willow market, clothes, and fruit baskets, furniture, hampers, and trunks, to the finest examples of split willow ware, wrought with a skill which gives them a real artistic value.

In America the market has a different aspect. Here a very large number of baskets are made of wood, some of woven pine, oak, ash, and elm strips, others constructed from broad veneers laid together at the bottom and fastened at the rim by a strip. Market, clothes, and laundry baskets are largely made of wood, and the willow is forced to be content with a limited share of the general trade. Rattan, too, has always enjoyed a high degree of favor, and has a permanent place in the American market. Baskets made from wood other than willow are much less durable and have not the combined lightness and elasticity which is so desirable. Rattan is quite as lasting as willow, but it is less rigid, and its rough surface soils quickly. It is also much more expensive.

On this continent, where economy of labor is of the first importance, the manufacture of those baskets intended to be filled but once, such as fruit baskets, etc., forms a class by itself, which lies necessarily entirely outside the field of the willow. In this case cheapness is the only essential, and the preparation of the material is entirely done by automatic machinery, while the hand process of manufacture is the simplest imaginable. A recent machine has entirely supplanted hand labor and reduced the cost.

WICKER FURNITURE.

For many years huge quantities of rattan have been used in the manufacture of furniture. In consequence a high degree of skill has been evolved, and the designs have become more and more elaborate. Willow is less easy to work, the result being that furniture made from it has greater simplicity of design. This, together with its durability, lightness, and beautiful color, has brought it into popular favor, and many important manufacturers have given up rattan entirely and gone over to willow. As a consequence the output has increased more than 100 per cent in the last ten years.

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[a] A very small quantity of wooden-strip baskets is manufactured in Sweden and Norway.

The manufacture of willow furniture requires a high degree of skill. (Figs. 21–22.) The lower cost of the willow is neutralized by the greater difficulty in working it, so that the two kinds of furniture enter the market on equal terms. Willow furniture is also made in Europe, but it is bulky and the transportation is very costly. As a result the import is not worth considering.

The industry in America is centered in New York and Boston. There are small concerns in various other places, but all the wholesale supply comes from a few large houses in these two cities. Wages are as high as $20 a week, but most of the workmen are foreigners; few young Americans adopt the trade, although really first-class men can always find work even at $3 per day. If the industry increases as it gives promise to, one of the greatest problems will be that of skilled labor.

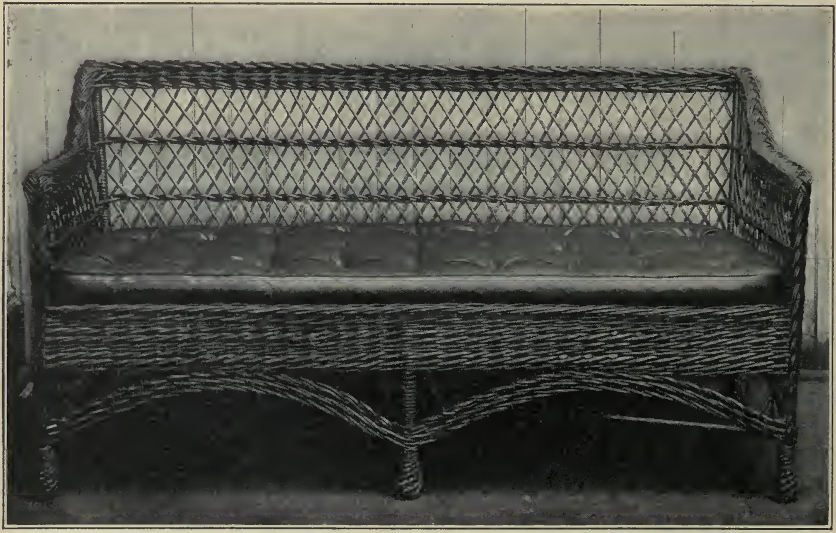

Fig. 21.—High-grade willow furniture.

Yet the question of the raw material is of even greater economic importance. At present all furniture makers use far more French willow than they do American. There are several reasons for this. The French willow is of a much more beautiful color, and is better sorted and easier to get in small sizes. The American is sorted and packed with less care, and the rods are apt to be large, the average grower not appreciating the value of small stock. The latter is more difficult to peel, and consequently more expensive to produce. As a result it is generally discarded, although there are growers who supply small rods at cost price just for the sake of the trade.

The average price for French willow is about 7 cents per pound. American willow of the best quality comes in four sizes, and is sold at from 5 to 7 cents a pound. The smallest size is hard to get, and the other sizes are not satisfactorily sorted.

Remembering that American willow is favorably looked upon by furniture makers and that most of their objections can be removed by greater care in its culture, every effort should be made to obtain possession of this most favorable market.

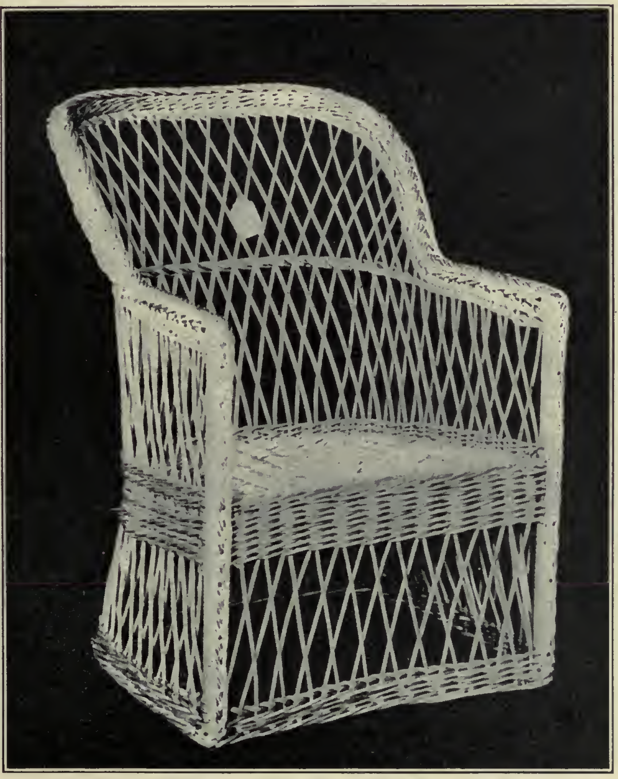

Fig. 22.—High-grade willow furniture.

HIGH-GRADE WILLOW BASKET WARE.

The makers of high-grade willow basket ware are generally in the larger cities. Through thrift, industry, and perseverance they have built up a regular custom trade. (Fig. 23.) Their establishments are found throughout the North, from the Atlantic to the great cities of the Mississippi. High wages in the far West make it more profitable to buy in the East, although there are several establishments in San Francisco and Sacramento. In the South, where large cities are fewer, such basket makers are to be found only in Richmond, Charleston, and New Orleans.

Almost without exception these workmen make no attempt to compete with the manufacturers of cheaper baskets, and confine themselves entirely to the production of goods for their particular customers.

One of the most serious questions which this phase of basket making must contend with is labor. Even in New York and Boston difficulty is found in getting good men at the wages which the basket maker can pay, and the farther west one goes the greater is the lack of good hands. The men available are nearly all foreigners, mostly Germans. Occasionally American-born workmen are to be found, but the long hours and comparatively small wages ($2 a day is a maximum) drive young men into other and more attractive fields. Throughout the country there is many a master basket maker who could enlarge his trade if he could secure more labor. As it is, he must be content to hold what custom he has.

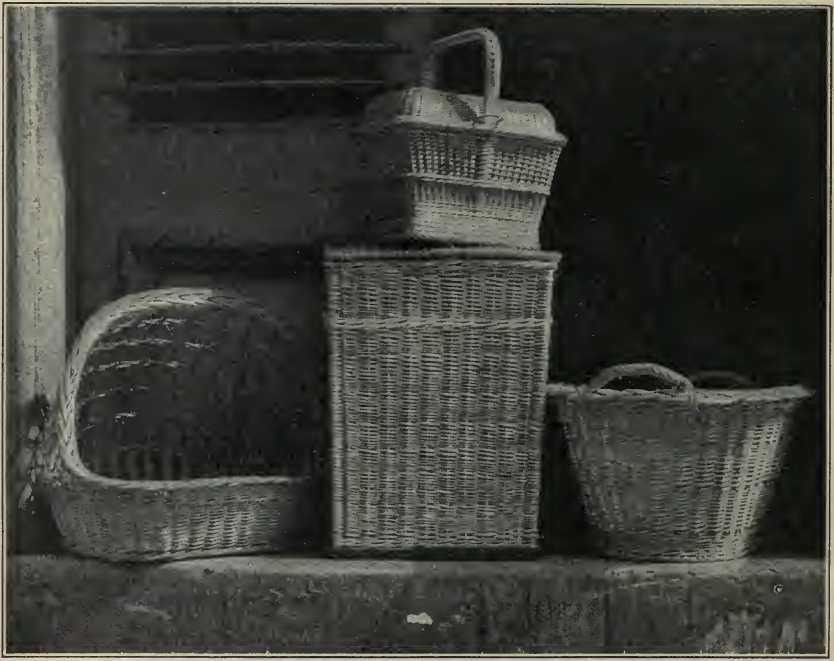

Fig. 23.—High-grade willow ware.

The source of supply of raw material varies in different parts of the country. In the East both foreign and domestic willows are largely used. The large furniture makers of Boston and New York also manufacture baskets, and for their best wares use French stock. This is done for the same reasons as those given in the case of willow furniture. Nevertheless they all use American willow and say they would use more if they could buy it, as it is heavier and more durable than the French. All willow used for fine baskets, and still more so for furniture, must be brilliant white, and for this reason only sap-peeled rods are to be considered. The foreign willow at present has a better color, but for basket ware American sap-peeled willow is white enough, and if it is properly sorted, not branchy, and with long, straight rods, it answers every purpose of the trade.

There is no reason why the custom trade of the great eastern cities should not be supplied by home growers who take the time to improve their methods. Baltimore is the seat of a large number of expert basket makers, who are almost entirely supplied by the willow growers of the neighborhood. Richmond is supplied by an establishment which has taken the wise step of growing its own willows, and with the most gratifying result. Indeed, these two cities, with their supply of raw material near at hand, are able to ship high-grade baskets to other parts of the country, and afford a very instructive example of what may be done in this line.

As one travels farther west the transportation cost raises the price of foreign willows, so that even in Cincinnati it stands at 7 to 8 cents a pound. As the best native stock of the neighborhood costs but 6½ cents and lower grades only 4 or 5 cents, it needs only quality to command the field. In Indiana, Ohio, and Kentucky the question is entirely one of better growing and a successful contest with dangerous insect pests. A few years ago the best willows sold at 3 cents a pound, but now can hardly be bought at 6. Some of the larger basket makers in St. Louis use French rods, but the vast majority of the stock comes from the neighboring willow-growing States. Chicago is supplied with a very good willow from Wadsworth, Ill., and from Indiana and Kentucky. The same is true of Milwaukee and other cities in the same district. One and all, the basket makers seem to prefer the American willow if it can be obtained.

The custom-made basket has a steady market throughout the country. If the basket maker can get good stock at a low price, there is no doubt but that he can enlarge his trade. For this reason there is a promising outlook for scientific willow culture.

LOW-GRADE WILLOW BASKET WARE.

The best quality of willow basket, it has been seen, has scarcely a competitor in the field. The demand for such goods, however, is comparatively limited. The great mass of the population are either unable or unwilling to pay a high price for household basket ware. It is to satisfy this demand that the wooden basket exists and has so large a sale. Nevertheless willow is known to be so superior to it for hand baskets, clothes baskets, hampers, etc., that people will buy it in preference if its price reaches a figure which represents, in comparison with the cheaper forms of basket ware, the ratio of durability between the two. To bring prices to this level has been the attempt of a large section of the basket-making population for many years, and upon them alone falls the brunt of the competition with wooden baskets, and also with the cheap willow product imported from Europe.

In order to gain a clear view of the situation, it is necessary to divide the manufacture of cheap willow baskets into two sections. The first of these is the wholesale basket industry in western New York State and the second the manufacture of cheap baskets in small isolated establishments in the great cities and throughout the country.

The basket industry about Syracuse, Rochester, and other western New York cities is different from that in any other part of America, and more nearly approaches that of certain sections of Europe. It is centered in the midst of an important willow-growing district, and is mainly in the hands of a few large dealers. These men buy the willows and give them out to the basket makers, who make them up into baskets at home, receiving a specified sum per dozen, according to size. The principal object in view is cheapness, and everything is done to reduce the cost to a minimum. The willows are steam peeled, a process which very much reduces the price, but which turns the rods a red-brown color and ruins them for all manner of fine work. There is no doubt whatever that it is European competition which sets the price of this basket ware, and which has reduced the New York basket industry to such a low margin of profit that its very existence is threatened. Certain large importing houses in New York have buyers continually in Europe, who procure large quantities of cheap wares at every opportunity. These baskets can be compactly stored and shipped at low rates, the import duty paid, and the goods put on the American market at a phenomenally low price.

The competition of the foreign basket is illustrated by the case of the willow growers and dealers of Syracuse, who about fifteen years ago, favored by the cheap price of willows, formed themselves into a stock company and began to assume control of the trade in America. Immediately the importers bought up a large stock of cheap baskets in Europe, underbid the American combination, and deprived them of their sales. The large number of baskets left over in the warehouse at Liverpool was set on fire—probably by those who feared for their next year's work—and since that time no attempt has been made at combination. To make matters worse, at that time the willows were sadly devastated by insects and the price of the raw material was consequently very much increased.

Although the import of foreign baskets sets the price of the American-made product, this import itself is not a growing one. The whole consumption of basket ware in America is not increasing, and besides, the foreign basket, to sell at so small a price as it does, must necessarily be of very low quality. For this reason it has lost favor, and the American basket is beginning slowly to assert itself. Certain basket makers even in the New York district sell their product for much more than the European basket ware brings. This is an approach to the class of the high-grade basket, but as yet the tendency is not marked; the great mass of the workmen are in active competition with the European product, because, even if it is not largely imported, it is always overhanging the market and preventing any rise in price. Nor is this the only depressing force which the cheap American basket must face in seeking a market. Certain grades of wooden baskets actively encroach on its field. Huge quantities of covered hand baskets are made of splints at a very low cost, and have a large sale. A wooden "satchel basket" can be bought for 70 cents, while a willow one of equal capacity costs $1.25 to $1.50. The willow basket is much more durable than the wooden one, but not enough so to make up for the difference in price. This is the case not only with hand baskets, but also with clothes, market, and bushel baskets. It may safely be said that the entire decrease in the willow basket output since 1890 has gone to swell the sales of the same article made of wood.

Nevertheless, the cheap grade of willow basket has a regular place in the market, and one necessary to the general trade. A reduction in the cost of the raw material would allow the dealer to pay a better price for making the baskets. Nor need this reduction in the cost of the raw material be carried out at the expense of the farmer. More scientific methods, a greater yield per acre, and a better knowledge of his market will give him a larger profit on his willows in the increased demand.

Although nowhere else is there so large a center as in western New York, there are basket makers scattered through the country districts of Pennsylvania and the Middle Western States as far as the Mississippi. These work under very much the same conditions as their colleagues in New York, using, as a rule, however, sap-peeled willow. Apart from a small sale in their neighborhood they all sell to the nearest large city, and here they invariably meet the French or German basket on sadly unequal terms. In Cincinnati, for instance, the large dealers can afford to sell a "nest" of four foreign baskets (three pecks, a half-bushel, a trifle more than a peck, and a half-peck) at 64 cents, while the American maker loses money by selling better made baskets for less than 90 cents, although he is compelled to sell at this price if he sells at all. Thus it is throughout the country.

In all the large towns small basket makers are found who sell low-grade baskets at a very low price. They are almost always foreigners who live in the simplest way and in the smallest space possible. Their material they obtain as cheaply as they can, and with the help of their whole families and by working long hours they are able to produce baskets which they sell in their neighborhood or peddle in the streets, probably making a very good profit. From this laborious, frugal class of foreigners have come nine out of ten of the successful, well-to-do master basket makers.

SUGGESTIONS FOR BASKET MAKERS.

In Europe basket ware is used for many purposes practically unknown in this country. In dairies and bakeries on the Continent and in England, eggs, buns, rolls, etc., are displayed in very delicately woven shallow baskets of the finest kinds, which are very beautiful and make the store much more attractive than ordinary vessels. Grocers often use willow hampers for dried fruits, nuts, etc. The hampers are made with one side higher than the opposite, so that the wares can be better seen. The hamper is set on short feet to keep it off the ground.

In England great quantities of split willow ware are used. Screen doors and office window screens are beautifully fashioned in willow, and even hotel washstand splashers are made out of the same material. Beautiful little mats for hot dishes at table are also made from split willow, to say nothing of very dainty bread baskets.

A half-bushel basket is made in England and Holland which is singularly durable for its weight. The bottom is arched, giving the whole basket great strength. Nurserymen ship their trees in baskets of unpeeled willow, the uprights of which project from the basket and are tied together over the top of the plant for its protection.

A very beautiful and light basket is made in Germany, with the sides formed simply of uprights strengthened by one or two single lines of weaving.

In England commercial travelers' sample boxes are made of willow, lined with waterproof leather or canvas, the corners and edges bound with rawhide. These trunks are very light, and are serviceable enough for almost any usage. Laundry hampers are also made on the same principle. Parcel trucks on the English railways are almost always of willow, and seem to render perfect service. Willow trunks and hampers are a feature of European traffic, and their use, particularly for suburban transportation, might become more general here.

SUMMARY STATEMENT.

The growing of basket willows was introduced into the United States some sixty years ago by German immigrants who settled in New York and Pennsylvania. The industry was soon extended to

Maryland and westward to Missouri and Iowa; it is now rapidly spreading over the nonarid regions of the far West. This industry, which has been languishing for a number of years, has recently taken a sudden leap and shows enormous possibilities. This is due entirely to improved methods of culture and to the introduction of new and choice varieties of basket willows The cost of production in the United States has been greatly reduced, while the quality of the rods has been improved. These results have brought a betterment of the condition of both the grower and the manufacturer.

In summarizing the essential considerations of this industry, it is important to call attention particularly to the specific instructions given in the bulletin regarding the planting, cultivating, harvesting, and marketing of basket willows. General instructions do not always apply to the special needs of some growers. Many details can be learned only by experience.

Soil and situation.—Great care should be taken in the selection of the soil and the location of the holt. Rich, permanently moist, sandy loam gives best returns, though ordinary moist sandy land often yields profitable crops of willows. Poor soils produce paying crops where there is a market for short rods. Avoid land on which water is stagnant during the summer. If by drainage the water level on such land can be lowered at least 6 feet below the surface, the situation may be considered appropriate. Do not plant willows in localities where early frosts occur. The tender shoots are easily injured by cold.

Preparing the ground.—Plow 10 or 12 inches deep in the fall, prior to planting the following spring. This turns the top layer of the soil so deep that weed seeds can not spring up. If rain is insufficient, irrigate the holt, if possible, but thorough drainage must be provided, as water must not stand on the surface. It is best also to keep the land well drained during the winter.

Variety and quality of willows.—Returns depend very largely upon the method of culture, but more upon the variety of willow planted. Willows with the most approved qualities should be planted, because the shoots of even the best varieties and in the most suitable soil grow brittle after the stools become old. The American green and Welsh willows are most generally planted. The rods of the former peel readily, split easily, are snow-white, hard, flexible, and heavy. They have a tendency to branch, however, and unless the stools are planted close together, a large percentage of the rods branch so much that they are often unfit for peeled stock. The Welsh willow yields less in bulk per acre than the American green, but surpasses the latter both in market value (because of better quality) and in specific weight. For planting along rivers to prevent erosion, Welsh willow is the best. The Lemley, or Caspian willow, is preferable for planting in poor, sandy land. In moist, rich, sandy loam it produces more than twice as much in weight as the Welsh willow. It is best to plant several varieties of willows in order to obtain a good crop of one or more each year, since all willows yield better crops some years than in others.

A good basket willow possesses the following characteristics:

(1) Ability to yield an annual and uniformly paying crop of rods.
(2) Flexibility.
(3) Productiveness, i. e., many shoots to each stool.
(4) Slender and branchless rods.
(5) Smooth and white wood after peeling.

Planting willow cuttings.—Cuttings for planting should be made from one-year-old shoots. The length of the slips is regulated by the condition of the soil. The richer the soil the shorter the cuttings may be. Generally they are made 8 inches long for moist, rich soil, and 12 inches for dry, sandy soil. Although it is generally advised to prepare cuttings just before planting, they may be made several weeks in advance and, partially buried in moderately moist sand, stored in a cold barn until needed. Bury the cuttings in sand to within 1 inch of the top. Care should be taken to have the buds point upward.

Plant early in the spring, as soon as the frost is out of the ground. In spacing the plants, the following principle holds for all willows and for all soils: The closer the cuttings are planted, the more valuable, i. e., more flexible, tough, slender, and branchless the rods become. On the other hand, they must not be planted so close that the soil in and between the rows can not be cultivated. As a general rule, cuttings should be spaced 9 inches apart in the rows and 20 inches between the rows. Willows with small leaves should be planted 6 by 18 inches or 5 by 15 inches apart. Otherwise they are likely to branch too much.

The number of cuttings required to plant an acre is as follows:

Distance apart in the rows.	Distance between the rows.	Number of cuttings per acre.
Inches.	*Inches.*	
5	15	83,635
6	18	58,080
9	20	34,846

Cultivating the holt.—The success of a plantation depends largely on sufficient soil moisture, freedom from weeds, and permanently loose soil. Cultivate early in the spring and as often as necessary to remove all weeds and to keep the soil loose. If this is done well for the first two or three years, there will be very little trouble with weeds thereafter, because the weeds are completely shaded out by the dense leaf development. Bind weeds and wild morning-glories are very troublesome in most holts, and must be removed. The holt can not be cultivated too often so long as the stools and shoots are not injured by the cultivator.

Harvesting the rods.—The best time for cutting the rods is between November 15 and February 15. Rods from one-year-old holts should be cut at the end of the first year, preferably when the ground is frozen. During the first year the root system is small and care must be taken in cutting not to pull up the stools. Keep knife sharp and make the cutting strokes clean and decisive. Cut close to the stools—but not into them.

Rods to be peeled are stood on end in a pit containing water from 4 to 6 inches deep and kept there until the sap rises (the buds open and leaves appear), when the bark can be removed. The peeled rods are quickly bleached and dried when exposed to the sun, after which they are sorted, tied in bundles, and stored in a dark, dry place. Frequently willow rods are steamed or boiled in water for three or four hours as a means of preparing for peeling, a method which loosens the bark and renders the peeling easy. Boiling or steaming gives the rods an undesirable dark buff color which makes them less valuable.

Rods are peeled by drawing them through a springy wooden or steel fork, shaped like a clothespin (fig. 10, 1–7), but larger. This loosens the bark in strands so that it can easily be removed by the hands.

Marketing willows.—Peeled rods may be sold to local basket makers or to large willow-ware makers, who are usually glad to buy home-grown instead of imported stock. For the larger market the rods must be white and properly sorted according to sizes in order to compete with the imported stock, which is of good color and consists of long, straight, branchless rods, carefully sorted into equal lengths and into grades of uniform quality. Those who sell to local basket makers are able to offer them at a lower price than those who have to ship to a distant market. The grower who sells to local consumers can also keep in constant touch with his customers and cater more successfully to their requirements in special varieties and grades of rods than can the grower whose product goes to larger markets.

Upon application, the Forest Service, Washington, D. C., will furnish to willow growers the names and addresses of the manufacturers of willow ware nearest to them.

FARMERS' BULLETINS.

The following is a list, by number, of the Farmers' Bulletins available for distribution. The bulletins entitled "Experiment Station Work" give in brief the results of experiments performed by the State experiment stations. Titles of other bulletins are self-explanatory. Bulletins in this list will be sent free to any address in the United States on application to your Senator, Representative, or Delegate in Congress, or to the Secretary of Agriculture, Washington, D. C. Numbers omitted have been discontinued, being superseded by later bulletins.

22. The Feeding of Farm Animals. PPp. 40.
24. Hog Cholera and Swine Plague. Pp. 16.
27. Flax for Seed and Fiber. Pp. 16.
28. Weeds: And How to Kill Them. Pp. 30.
30. Grape Diseases on the Pacific Coast. Pp. 15.
32. Silos and Silage. Pp. 30.
33. Peach Growing for Market. Pp. 24.
34. Meats: Composition and Cooking. Pp. 31.
35. Potato Culture. Pp. 24.
36. Cotton Seed and Its Products. Pp. 16.
42. Facts About Milk. Pp. 32.
44. Commercial Fertilizers. Pp. 38.
47. Insects Affecting the Cotton Plant. Pp. 32.
48. The Manuring of Cotton. Pp. 16.
49. Sheep Feeding. Pp. 24.
51. Standard Varieties of Chickens. Pp. 48.
52. The Sugar Beet. Pp. 48.
54. Some Common Birds. Pp. 48.
55. The Dairy Herd. Pp. 30.
56. Experiment Station Work—I. Pp. 30.
58. The Soy Bean as a Forage Crop. Pp. 24.
59. Bee Keeping. Pp. 48.
60. Methods of Curing Tobacco. Pp. 24.
61. Asparagus Culture. Pp. 40.
62. Marketing Farm Produce. Pp. 31.
63. Care of Milk on the Farm. Pp. 40.
64. Ducks and Geese. Pp. 55.
65. Experiment Station Work—II. Pp. 32.
66. Meadows and Pastures. Pp. 30.
69. Experiment Station Work—III. Pp. 32.
71. Essentials in Beef Production. Pp. 24.
73. Experiment Station Work—IV. Pp. 32.
74. Milk as Food. Pp. 39.
77. The Liming of Soils. Pp. 24.
78. Experiment Station Work—V. Pp. 32.
79. Experiment Station Work—VI. Pp. 27.
80. The Peach Twig-Borer. Pp. 16.
81. Corn Culture in the South. Pp. 24.
82. The Culture of Tobacco. Pp. 22.
83. Tobacco Soils. Pp. 23.
84. Experiment Station Work—VII. Pp. 32.
85. Fish as Food. Pp. 32.
86. Thirty Poisonous Plants. Pp. 32.
87. Experiment Station Work—VIII. Pp. 32.
88. Alkali Lands. Pp. 23.
91. Potato Diseases and Treatment. Pp. 15.
92. Experiment Station Work—IX. Pp. 30.
93. Sugar as Food. Pp. 31.
96. Raising Sheep for Mutton. Pp. 48.
97. Experiment Station Work—X. Pp. 32.
98. Suggestions to Southern Farmers. Pp. 48.
99. Insect Enemies of Shade Trees. Pp. 30.
100. Hog Raising in the South. Pp. 40.
101. Millets. Pp. 30.
102. Southern Forage Plants. Pp. 48.
103. Experiment Station Work—XI. Pp. 30.
104. Notes on Frost. Pp. 24.
105. Experiment Station Work—XII. Pp. 32.
106. Breeds of Dairy Cattle. Pp. 48.
107. Experiment Station Work—XIII. Pp. 32.
110. Rice Culture in the United States. Pp. 28.
112. Bread and Bread Making. Pp. 40.
113. The Apple and How to Grow It. Pp. 32.
114. Experiment Station Work—XIV. Pp. 28.
116. Irrigation in Fruit Growing. Pp. 48.
118. Grape Growing in the South. Pp. 32.
119. Experiment Station Work—XV. Pp. 30.
120. Insects Affecting Tobacco. Pp. 32.
121. Beans, Peas, and Other Legumes as Food. Pp. 38.
122. Experiment Station Work—XVI Pp. 32.
124. Experiment Station Work—XVII. Pp. 32.
125. Protection of Food Products from Injurious Temperatures. Pp. 24.
126. Practical Suggestions for Farm Buildings. Pp. 48.
127. Important Insecticides. Pp. 46.
128. Eggs and Their Uses as Food. Pp. 40.
131. Household Tests for Detection of Oleomargarine and Renovated Butter. Pp. 10.
132. Insect Enemies of Growing Wheat. Pp. 38.
133. Experiment Station Work—XVIII. Pp. 32.
134. Tree Planting in Rural School Grounds Pp. 32.
135. Sorghum Sirup Manufacture. Pp. 40.
137. The Angora Goat. Pp. 48.
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139. Emmer: A Grain for the Semiarid Regions. Pp. 16.
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142. Principles of Nutrition and Nutritive Value of Food. Pp. 48.
144. Experiment Station Work—XIX. Pp. 32.
145. Carbon Bisulphid as an Insecticide. Pp. 28
147. Winter Forage Crops for the South. Pp. 40
149. Experiment Station Work—XX. Pp. 32.
150. Clearing New Land. Pp. 24.
152. Scabies in Cattle. Pp. 32.
154. The Home Fruit Garden: Preparation and Care. Pp. 16.
155. How Insects Affect Health in Rural Districts. Pp. 19.
156. The Home Vineyard. Pp. 22.
157. The Propagation of Plants. Pp. 24.
158. How to Build Small Irrigation Ditches. Pp.28.
159. Scab in Sheep. Pp. 48.
161. Practical Suggestions for Fruit Growers. Pp. 30.
162. Experiment Station Work—XXI. Pp. 32.
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165. Silkworm Culture. Pp. 32.
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173. Primer of Forestry: Pp. 48.
174. Broom Corn. Pp. 30.
175. Home Manufacture and Use of Unfermented Grape Juice. Pp. 16.
176. Cranberry Culture. Pp. 20.
177. Squab Raising. Pp. 32.
178. Insects Injurious in Cranberry Culture. Pp.32.
179. Horseshoeing. Pp. 30.
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183. Meat on the Farm: Butchering, Curing, and Keeping. Pp. 37.
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196. Usefulness of the American Toad. Pp. 16.
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FARMERS' BULLETIN 342.

Experiment Station Work,

XLIX.

Compiled from the Publications of the Agricultural Experiment Stations.

CONSERVATION OF SOIL RESOURCES.
POTATO BREEDING.
DISK-HARROWING ALFALFA.
THE MONTREAL MUSKMELON.
STORAGE OF HUBBARD SQUASH.
FIG CULTURE IN THE SOUTH.
MUSHROOM GROWING.
PRESERVING WILD MUSHROOMS.
COOKING BEANS AND OTHER VEGETABLES.
A MODEL KITCHEN.

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EXPERIMENT STATION WORK.

Edited by W. H. Beal and the Staff of the Experiment Station Record.

Experiment Station Work is a subseries of brief popular bulletins compiled from the published reports of the agricultural experiment stations and kindred institutions in this and other countries. The chief object of these publications is to disseminate throughout the country information regarding experiments at the different experiment stations, and thus to acquaint farmers in a general way with the progress of agricultural investigation on its practical side. The results herein reported should for the most part be regarded as tentative and suggestive rather than conclusive. Further experiments may modify them, and experience alone can show how far they will be useful in actual practice. The work of the stations must not be depended upon to produce "rules for farming." How to apply the results of experiments to his own conditions will ever remain the problem of the individual farmer.—A. C. True, Director, Office of Experiment Stations.

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EXPERIMENT STATION WORK.[a]

CONSERVATION OF SOIL RESOURCES.[b]

The conservation of the natural resources of the soil constitutes one of the elemental problems of modern scientific agriculture.

In the United States agricultural operations have generally been conducted without much consideration for the soil inheritance of future generations. Lands have been denuded of trees, and the soils thus more or less exposed have in many localities been washed by torrential rains or melting snows into the rivers, leaving bare rocks behind or soils too deficient in plant food for profitable agricultural purposes. Indifferent methods of cultivation have produced effects similar to those caused by deforestation. In some places rains have frequently washed soils improperly cultivated, while in others winds have drifted the soils, so that at the present time the problem of conserving what is left of the natural resources of the soil is of great economic significance.

The agricultural experiment stations have made efforts to work out the best methods of conserving the natural resources of the soil. A vast amount of work has been done to improve excessively cropped or washed lands by means of the scientific application of fertilizers and the growing of green manures. This, however, is a work of soil building rather than of conserving the forces already in soils, but the following statement of experiments shows that the stations have long been engaged in work looking to the scientific conservation of the natural resources of soils. In this article attention is directed solely to soil conservation as a basis of agriculture, and no consideration is given to the work done by the stations in the conservation of the moisture and plant-food contents of soils.

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[a] A progress record of experimental inquiries, published without assumption of responsibility by the Department for the correctness of the facts and conclusions reported by the stations.

[b] Compiled from Alabama Tuskegee Sta. Buls. 6, 11; Mississippi Sta. Buls. 29, 66, 108; South Carolina Sta. Bul. 32; Tennessee Sta. Bul., Vol. III, No. 4; Wisconsin Sta. Bul. 42. See also U. S. Dept. Agr. Farmers' Buls. 245 and 327.

PREVENTION OF SOIL WASHING.

Soil washing occurs on rolling lands and is generally the result of heavy rains falling on cultivated fields after crops have been removed. The steeper the grade the deeper, usually, are the washed-out gullies, so that after a few years of such washing soils are largely carried away, leaving only bare rocks, a slightly fertile subsoil, or, at best, a soil only a few inches in depth. Such lands are known as " washed " or " galled " lands.

There are various ways for preventing surface washing, such as embanking, tile drainage, deep culture, subsoiling, sodding, and planting to crops.[a] But when soils are washed, two methods of reclamation are generally practiced. The first step is to eliminate the gullies for the better working of the land. This is accomplished by filling with stumps, brush, and an occasional load of earth, and briars and other plants will grow in them. Finally, by plowing and a few embankments, if necessary, the surface can be made smooth by the time the soil is ready for cultivation again. The land is now prepared for the prevention of washing. Observations have shown that plant growth prevents the washing away of soils, and the laying down of such fields in permanent pasture is one method of overcoming the difficulty of washing. Even " the losses which are sustained through the leaching of underground water may be largely prevented, though not entirely. This loss is best prevented by keeping the ground always covered by a growing crop, especially during the fall and winter, when this loss is likely to be greatest. Organic matter and clay have a tendency to fix the plant-food ingredients and prevent their being carried out by the water, and this is the reason that land with a clay subsoil is well adapted to improvement."

Under the conditions which exist, however, in soil-washing regions, the securing of a stand of crops on such lands is an exceedingly difficult undertaking. The Tennessee Station made a large number of experiments during the years 1878 to 1890 with many crops to prevent the washing of the embankments as well as the soil between embankments. Most of these experiments resulted in failure, but the following is a noteworthy exception, as described by the investigator:

> Becoming convinced of the great value of mulch in saving young grass and clover from being scalded out on raw clay exposures during summer, * * * all the sedge grass, weeds, etc., on the place [were] mowed down and stacked up for that purpose during the fall of 1889. During this fall also and the winter succeeding * * * the galled places on the farm not already under treatment were leveled, plowed, subsoiled, and manured at the rate of 20 good

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[a] For descriptions of methods of preventing soil washing by means of graded embankments, level embankments, and so-called terraces, see Alabama Tuskegee Sta. Bul. 6, pp. 4, 5; Mississippi Sta. Buls. 66, pp. 13–18; 108, pp. 4–11.

loads of manure per acre on the surface. In the spring of 1890 this was thoroughly worked in with harrow and the whole seeded to clover 6 pounds, red top 1 bushel, bluegrass 1 bushel per acre, with 100 pounds good complete fertilizer per acre. This seeding was killed by a March freeze, and it was reseeded as before, but without any more fertilizers. In May the whole was carefully mulched with sedge grass.

The result was considered a decided success, and the conclusion was that while rather costly, the method altogether, perhaps, furnished the cheapest and most satisfactory means of reclaiming galled hillsides.

Probably the most effective method of conserving the natural resources of washed lands is by means of terracing. Three methods of terracing land have been developed. One is to have a system of level embankments about 4 feet wide and 18 inches high, the rows to be run as near on a level as possible and parallel to the embankments. This method is employed where both the surface and subsoil are porous and absorb water rapidly. It aims to hold the water practically where it falls until soaked up by the soil.

A second system of terracing proceeds on the basis of letting the surplus water run, but by means of rows and embankments make it run slowly. To accomplish this each embankment and each row is given a little fall, the embankments being required to do the bulk of the work. To make this system operate satisfactorily there should be two systems of embankments, the rows running parallel to the main embankments and crossing the shorter ones.

A third system aims at producing, by the method of plowing, real terraces or comparatively level areas on the side or slope of the hillside. To accomplish this lines of level are run the same as in system one, but no embankments are made. A hillside plow that turns all furrows downhill is always used in breaking. Wherever the lines of level have been run, leave an unplowed space 12 to 15 inches wide at each plowing. Let the soil of the first furrow in each terrace space be turned onto the unplowed space, thus elevating this space. If the plow breaks 6 inches deep, the grade or fall of each terrace space or area will be reduced 1 foot every time the land is broke. In carrying out this system the rows are run on a level. It only differs from the system first described in not making an embankment to start with and in the use of hillside plow in breaking.

The perpendicular fall between these terraces should be about 4 feet, and the same is true of the system of level embankments first described. Where both the embankments and rows are given a fall, as described in the second system, the perpendicular fall between embankments may be 8 feet.

The second system, with embankments and rows having a small fall to conduct surplus water slowly, is in use on the [Mississippi] Station grounds. The embankment is essentially a very much enlarged hillside ditch, the bottom of which being 4 to 6 feet wide and the bank from 4 to 6 feet wide and about 18 inches high. This broad, shallow ditch and broad embankment can be crossed with rows and implements and so cultivated as to lose very little land and can be kept as free from weeds and grass as other parts of the field.

The Mississippi Station has reported data as to the cost of making terraces and filling gullies. The former averaged $0.07 per rod, while all the gullies, large and small, on a badly washed hillside were filled for $5.62 per acre. When it is considered, therefore, that land otherwise useless can be brought under cultivation at a cost of a few dollars per acre, and that by proper care thereafter this land can be kept in good condition with little expenditure of money and labor, the first outlay seems very insignificant compared with the great wealth-producing power thus afforded to a community by these means of conserving the natural resources of the soil.

PREVENTION OF SOIL DRIFTING.

Light sandy soils and sandy loams are often destructively affected by winds. Large tracts of land have been rendered practically useless for the growing of crops, and crops growing in fine condition have been ruined by the drifting of the soil. These conditions apply in many western States where large areas of land covering hundreds of square miles, which experience has proven to be capable of profitable cultivation, are subject to the destructive effects of winds.

The physical explanation of these phenomena is given by Prof. F. H. King as follows:

> Long continuous fields of dry, naked, sandy soil, in hot weather, have a peculiar effect upon the air currents sweeping across them. The sand itself becomes very hot and greatly expands the air coming in contact with it, making it relatively lighter than the colder, much more rapid current of air sweeping along above, and the result is the warm air suddenly blisters, as it were, and being lifted from the ground, a cold current of rapidly moving air from above strikes obliquely upon the surface, raising a cloud of fine dust into the upper swifter current in which the particles are borne away, while the coarser grains are rolled along the surface until the air is slowed down by its friction upon the ground. This air coming down from above has a peculiar parching effect, too, for it is naturally drier than the ground air and, striking the hot soil, its parching power is greatly augmented by the heat it so receives. Grass-covered surfaces and damp soils do not become overheated as the dry sands do, and the result is, during windy times, the air moves across them in a more steady and less turbulent manner.

In consequence of such conditions occurring over extensive areas of soil in parts of Wisconsin Professor King, of the Wisconsin Station, made a careful study of the influence of shelters and methods of cultivation as means of protecting the fields. From these investigations the following practical suggestions are made regarding the conservation of these lands for agricultural purposes:

1. **Frequent rotation in long, narrow lands.**—If light soils are cultivated in long, narrow lands, not wider than 15 to 20 rods, alternating with similar strips of grass, preferably clover, such destructive effects as above indicated can not occur, or only to a slight extent. If possible, the fields should extend in a north and south direction rather than east and west. The nature of the lands renders cultivation

one way satisfactory and a saving of labor. The rotation should aim " to always have in the spring a field of grass to the west of those which are to be sowed to grain and seeded to clover, and this is secured by always planting potatoes or corn on clover sod, for the latter going in later in the season allows the clover to stand as a protection while the grain is getting started when the most serious damage is done and at the same time furnishes a green manure to plow in to increase the humus of these soils, in which they are naturally so deficient."

2. Increasing the water-holding power of the soil.—The small water-holding power of these soils is the cause of drifting, and makes it difficult to get and maintain a good stand of clover. Moreover, the more these fields are allowed to drift the less their water-holding power becomes and the greater their tendency to drift in succeeding years. The presence of organic matter in the soil increases its water-holding power, so that the use of plenty of barnyard manure and the plowing under of green crops and weeds are recommended.

3. Leaving the ground uneven after seeding.—The smoother the ground the greater is the velocity of the wind close to the surface and, therefore, the greater is the power of the wind to take up and carry away the soil particles. Observations show that fields left smooth after seeding drift badly, while in uneven fields there is no appreciable drifting. Running a harrow over smooth fields stops drifting at once where the soil is stirred. Sowing the seed with the drill north and south also has a tendency to lessen drifting very materially.

4. The preservation of wooded belts in north and south strips.—Where clearing is being done, strips running north and south should be left as windbreaks to stop the drifting and to make sure a crop of clover or grass. " The width of the wooded strips to be left as hedgerows would depend upon the character of the soil and upon the width of the strips that are cleared; the lighter the soil is and the wider the cleared fields the broader the hedgerows should be."

5. The planting of windbreaks.—Planting of trees on the section and quarter section lines of prairie lands, on roadsides, along the borders of fields, and as shelter belts on light lands that have been entirely cleared of trees is recommended. Trees that do well on light soils are box elders, jack pines, apples, plums, English filberts, etc.

Considered in its general aspects, the work which the agricultural experiment stations have done along the lines of preventing the washing and drifting of soils is of great economic significance. Means for preventing the further waste of the natural resources of the soil have been discovered. If these principles are put into practice, large tracts of land now useless can be brought under cultivation, and if these lands are worked in accordance with methods of restoring and maintaining soil fertility, which the stations and this Department have discovered and published, the extent of the wealth-producing power thus conserved to the farmers of the United States will be enormous.

POTATO BREEDING.[a]

In total value of annual production the potato crop usually ranks sixth among our field crops, standing between oats and barley. The yearly consumption of potatoes increases as the population grows, and not infrequently the annual imports exceed the annual exports. Further, in only six years since 1866 has the average yield for the whole country been over 100 bushels per acre, while ordinarily this is considered a small yield, especially by market growers. The importance of the potato crop, therefore, as well as the comparatively low average yield per acre would seem to warrant the use of improved methods to increase the annual production. In addition to employing improved cultural methods, this may be accomplished by improving the productivity of the crop.

Dr. H. J. Webber, in a recent bulletin of the New York Cornell Station, points out that even for New York State alone every means should be used to increase the production, and among other results those secured by Prof. C. W. Waid, of the Ohio Experiment Station, indicate the possibility of greatly improving the crop by tuber or bud selection. Professor Waid's work was begun in 1903, and the results obtained during three years are here summarized:

In 1904 10 hills each were planted from seed selected from 10 heavy yielding hills, and likewise 5 hills each from seed selected from 20 low-yielding hills of the crop of 1903. These 100 hills of each group were compared with 100 hills planted from seed not selected with reference to individual hills. In 1905 and 1906 this was repeated, the seed having been selected respectively from the high-yielding and low-yielding hills of the preceding year's crop. The results are briefly given in the following table:

Results with seed potatoes from high-yielding and low-yielding hills of Carman No. 3.

Source of seed.	Yield of 100 hills.				Number of tubers in 100 hills.			
	Total, 1904.	Total, 1905.	Total, 1906.	Average, 1904–6.	Total, 1904.	Total, 1905.	Total, 1906.	Average, 1904–6.
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*				
High-yielding hills	125	173	116	138	781	865	676	774
Check rows	115	136	79	110	713	630	479	607
Low-yielding hills	84	75	61	73	566	546	364	492

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[a] Compiled from New York Cornell Sta. Bul. 251; Ohio Sta. Bul. 174.

The average yield of the 100 heavy hills was 138 pounds as compared with 110 pounds for the unselected seed and 73 pounds for the seed tubers from the light-yielding hills.

As environment has a great influence on the potato, Doctor Webber advises that farmers, especially those growing potatoes extensively, determine by test the variety best suited to the locality or even to the particular farm on which the crop is produced. When the best variety available has been found a good foundation for breeding work has been laid. In fact, in plant breeding the variety or strain with which breeding work is begun is known as the foundation stock. The use of the following method is urged by Doctor Webber for carrying on the work from this point:

> (1) Examine a large number of tubers of the variety selected as the foundation stock and decide on the most desirable shape and type of tuber. In general a moderately large tuber, which is oblong or somewhat cylindrical in shape and oblong in cross section is considered most desirable. A spherical tuber if sufficiently large to be desirable is so thick that in cooking the outside is liable to become overdone before the interior is properly cooked. A tuber with shallow eyes, netted surface, and white color is also usually preferred.
>
> (2) When the ideal character and size have been determined, examine a large number of tubers and pick out a thousand or more having this size, shape, and general character. * * * These are to be used as the seed for planting the selection plat and the number selected should correspond to the size of the plat which it is desired to plant, four hills being planted with each tuber. There should certainly not be less than 1,000 and a much larger number is very desirable. The prospective breeder should remember that success in breeding work depends upon selecting the one individual that gives the very highest yield possible under the conditions, and the larger the number of individuals examined the more likely is he to discover the one producing the maximum yield which will give a valuable new strain. * * *
>
> (3) The planting should be arranged in such a way as to secure a test of the productivity of each tuber. * * * Cut each tuber into four uniform-sized pieces, making each cut longitudinally so that each piece will contain an equal proportion of the basal end and apical end of the tuber. Plant four hills with each tuber, one piece in a hill. These should be planted consecutively in each row, beginning at one end, so that starting at that end the first four hills will be from one tuber, the second four hills from another, and so on throughout the length of the row. The object in planting this way is so that the four hills can be dug together and the total product weighed to obtain a measure of the productivity of the seed tuber planted. Probably the best way to plant these is to drop the selected tubers one to each four hills and then go over the row and cut each tuber and plant its quota of four hills. The hills in the row should be planted somewhat farther apart than in ordinary planting, probably from 20 to 24 inches. If this is not done a somewhat greater distance than ordinary should be left between each 4-hill tuber unit. The writer would advise that one hill be left unplanted between each 4-hill unit. It would doubtless be convenient and desirable to have the plants in rows both ways to facilitate digging. For this selection plat of potatoes choose a field of moderately good fertility and as uniform throughout in soil as is possible to obtain.

The breeding plat is fertilized and cultivated exactly like the ordinary crop. When the vines begin to mature, but while they are yet green, the 4-hill units showing the most vigorous growth and at the same time freedom from, or at least resistance to disease are selected and marked, preferably with a stake. Later each 4-hill unit which is the progeny of one tuber is dug separately and the tubers of the four hills are carefully kept together. If the particular tuber unit is marked as one of the best, the same stake may be used to mark the product. When the entire crop of the breeding plat is dug, the 50 to 100 tuber units best in yield, uniformity of product, color, shape, etc., are selected. For this work the following directions are given:

(1) Go over the field and study the tuber units in a gross way until you have well in mind the variations in yield and the general uniformity of the tubers in the various tuber units. Remember that total yield is not the only important character. What one wants is to discover those tuber units which have the largest yield of good merchantable potatoes of the best shape and appearance. Size up the field as a whole with reference to these characters.

(2) Go over each row carefully and throw out all of those tuber units which can be clearly seen to be inferior. * * * For the interest of the grower, however, it would be well to weigh the product from some of the light yielding tuber units and preserve the figures as a matter of showing the extent of variation occurring. By this first discarding process the number of tuber units will probably have been reduced to two or three hundred. It is very probable that in some cases one or more of the hills of a 4-hill tuber unit will not grow. In such cases the tuber unit will have to be judged in proportion to the number of hills actually grown.

(3) Now, provide yourself with scales of some handy pattern like the ordinary counter scales used by grocers, with which the product of each tuber unit can be easily and quickly weighed. A satisfactory scale should weigh accurately to at least a half ounce. Weigh the product of the remaining tuber units, examine the tubers more carefully as to their character and uniformity of size in the tuber unit, and select about fifty of the best units. These fifty units should naturally be from those marked as having good healthy vines in the first examination, before digging, unless all of the vines at that time were in fairly good condition. In making these final selections if some hills in a tuber unit are missing the comparative yield can be easily calculated. If one hill is missing, a comparative yield for four hills is obtained by increasing the weight from the three hills by one-third. If two hills are missing, a comparative yield for four hills would be double that obtained from the two hills. If more than two hills are missing, discard the unit entirely.

The product of the tuber units selected should then be placed in paper bags, the product of one tuber unit being placed in a bag. A good bag for the purpose is the 12-pound manila paper bag used by grocers. Number each tuber unit consecutively and place this number on the bag. In your notebook record under the number of each tuber unit the number of large, medium-sized, and small tubers, and the total weight of the product. The bags containing the seed should then be placed in suitable storage where they will not be torn and the tubers mixed. The tubers from the best discarded tuber units should be retained to plant the general crop the next year.

For the second year's planting of the breeding plat the 10 best tubers of each of the 50 select tuber units, as judged by the standard type of tuber, are selected. Each tuber unit is planted in a row by itself, and as each tuber is cut longitudinally into four equal-sized pieces, the 10 select tubers will make a row of 40 hills, and if 50 tuber units were selected the breeding plat would contain 2,000 hills. Each row receives the number of the tuber unit from which it is planted. About every tenth row may be planted with unselected seed for comparison. The selections are made the same way as the year before. At the time of digging the yield of each unit is weighed and the number of large, medium, and small tubers recorded. This record will show the tuber unit of the original selection which has given the best results. The 50 best tuber units are again selected, the tubers of each kept separately in a paper bag and each bag numbered with the number of the original tuber unit, which is also the number of the row, and with the number of the tuber unit of each row as grown in this year's plat, as follows: 1-1, 1-2, 1-3, etc., for the tuber units from the first of the 40 rows; 2-1, 2-2, 2-3, etc., for the second row, and so on to the units of the last row, numbered 40-1, 40-2, 40-3, etc. The performance record of each tuber unit should be associated with its number.

All the good tubers of the tuber units not selected should be used for planting a multiplication plat the third year, from which enough seed can be grown to plant the general crop the fourth year. The ten best tubers of each selected tuber unit are again picked out for planting the next year's breeding plat.

The third year the breeding plat is planted according to the same method just described for the second year. The multiplication plat which may be grown this year does not require any special method of cutting and planting the tubers, as any desirable method will do. In the fourth and succeeding years the work is continued along the lines laid down.

It is pointed out that as heavier-yielding strains appear all further selections should be made from these strains, and that in this way, as the work progresses, many of the original strains will be entirely discarded. As an illustration of the appearance of such strains, further results obtained by Professor Waid, as given in the table below, are presented. The figures given for 1905 and 1906 represent the average yield of original and duplicate tests.

Yields from seed selected from high-yielding hills of Carman No. 3 potatoes.

Hill No.	Yield of selected hills, 1903.		Total for 10-hill group, 1904.		Total for corresponding 10-hill group, 1905.		Total for corresponding 10-hill group, 1906.		Average 10-hill groups, 1904–6.	
	Lbs.	*Oz.*	*Lbs.*	*Oz.*	*Lbs.*	*Oz.*	*Lbs.*	*Oz.*	*Lbs.*	*Oz.*
1	2	8.0	13	12.0	16	3.0	9	4.8	13	1.3
2	2	13.0	15	4.5	15	9.0	9	.5	13	4.7
3	2	10.5	12	1.5	18	3.0	10	14.0	13	11.5
4	2	2.5	11	15.0	17	11.0	11	1.8	13	9.3
5	2	3.0	12	8.5	16	9.0	11	10.3	13	9.3
6	2	1.0	10	9.5	15	.0	14	3.3	13	4.3
7	3	1.0	13	8.5	18	7.0	15	11.0	15	14.2
8	2	7.0	10	11.5	18	1.0	13	4.3	14	.3
9	2	1.5	12	14.5	19	10.0	11	6.0	14	10.2
10	1	14.0	12	0.5	18	8.0	10	5.0	13	9.8

The table shows that hill No. 7, which had the highest yield of the original ten hills selected, in each of the three years gave a very high yield and the highest average yield for the three years.

It seems evident from these results that by the simple method of selecting seed potatoes from the most productive hills for a series of years the productiveness may be profitably increased. The farmer can hardly afford to neglect so easy and efficient a means of increasing his profits, but will undoubtedly find it to his advantage to study the practical methods most applicable to his particular conditions.

On this point Doctor Webber says:

> For many years farmers have given careful attention to the methods of seeding, cultivation, manuring, and the like, but have generally neglected to give any careful attention to the methods of seed selection or breeding. They have universally recognized the importance of stock breeding and on all dairy and stock farms more or less careful attention has been given to the matter of breeding and improvement of the strain grown. To every farmer the field of breeding, whether in plants or animals, furnishes an interesting and profitable diversion. Plant breeding especially should become a farmer's fad. Few can afford to breed animals in the extensive way necessary to secure important results, owing to the expense. No farmer, however, is so poor but that he can have his breeding patch of corn, wheat, or potatoes. Indeed, if they but knew it, they can ill afford not to have such a breeding patch to furnish seed for their own planting.

DISK-HARROWING ALFALFA.[a]

The disking of alfalfa is a common practice, and seems to be an especially effective means of destroying weeds and breaking up the silt blanket deposited in cases where muddy water is used for irrigation. The ordinary disk harrow is widely used for this purpose, but R. H. Forbes, in a bulletin of the Arizona Station, states that a special machine " for the cultivation of alfalfa has been devised on the principle of the disk harrow, but with rows of strong spikes or digging teeth in place of the continuous edges of disks. These machines are stated to be in successful operation in Australia and South Africa, and one form * * * was introduced into Arizona in 1907. * * *

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[a] Compiled from Arizona Sta. Bul. 57, p. 256; Kansas Sta. Bul. 155.

"One man with an 8-foot machine and four horses will get over 8 to 10 acres of alfalfa in a day. This work may be done in winter when teams are more at leisure; but it is probable that in summer also, after cutting and before irrigating, an occasional disking, to break up the sediment blanket, may be well worth while, especially on the upper ends of alfalfa fields."

In South Africa the necessity of disk cultivation is recognized to the extent of having contests in which prizes are given for the machine most closely meeting the requirements.[a]

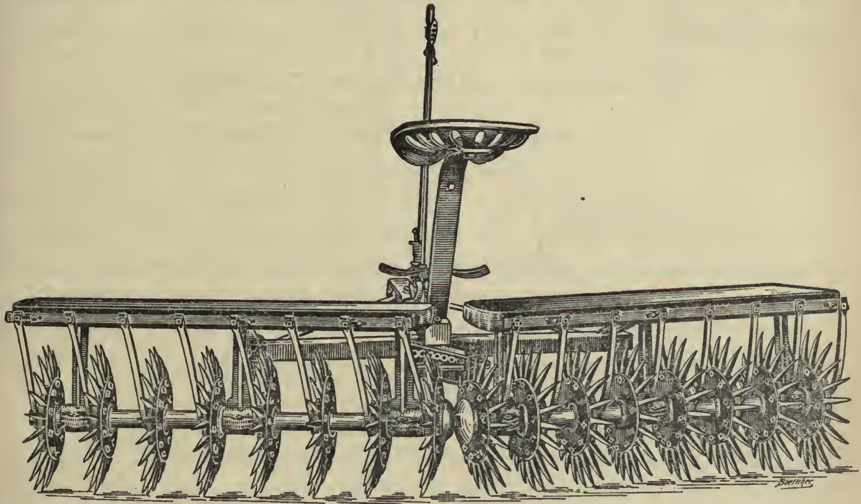

FIG. 1.—The alfalfa harrow.

A. M. Ten Eyck, of the Kansas Station, considers the cultivation of alfalfa desirable, and recommends disking in the early spring. He found "that less injury was done the alfalfa and the best work accomplished by setting the disks rather straight and weighting the harrow so as to make it cut 2 or 3 inches deep;" then cross-disking the field and harrowing it with the common straight-tooth harrow. He states that "the common disk-harrow is more generally used than any other implement to cultivate alfalfa, and when properly adjusted does good work. The spike-tooth disk, known as the 'alfalfa harrow' [fig. 1], was used on the alfalfa fields at the experiment station farm during the seasons of 1907 and 1908. This harrow does good work when properly adjusted, and is perhaps a better implement for this purpose than the common disk-harrow."

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[a] Agr. Jour. Cape Good Hope, 32 (1908), No. 4, p. 458.

The ends attained by disking alfalfa are thus concisely stated by Professor Forbes:

> At a trifling cost, varying according to individual circumstances, the disk-harrow splits and spreads the crowns of alfalfa plants, causing them to develop additional tops; it destroys the egg deposits and larvæ of certain injurious insects; it destroys weeds; it breaks up the silt blanket resulting from the use of muddy irrigating water, allowing better penetration of water and air to the roots of the crop; it loosens up certain dense soils; and to some extent it incorporates beneficial sediments and fallen alfalfa leaves with the soil.

As one of the most serious obstacles to the successful culture of alfalfa, particularly in the Eastern United States, is the crowding out of the plants in the earlier stages of growth by weeds, the introduction of implements and methods which will destroy or control the weeds is of great importance. The use of the disk harrow as described above seems to offer an efficient and practical means of securing this result.

THE MONTREAL MUSKMELON INDUSTRY.[a]

In a recent bulletin of the Vermont Station, Prof. W. Stuart states that for years a few Canadian muskmelon growers have enjoyed an almost exclusive control of the large eastern markets of the United States for their product. These growers, through carefully selected stock and skillful cultural methods, are able to produce a melon of unusual excellence over a season extending from the middle of July to frost. These melons command fancy prices ($8 to $15 per dozen wholesale), and even at such prices the Canadian growers are not able to supply the American demand.

It is quite generally believed that the Montreal muskmelons can be grown successfully only on a certain limited area on the island of Montreal. While the conditions of soil and climate may be especially favorable there, it seems reasonable to think that much of the success of the Canadian growers is due to their willingness to take infinite pains at every stage of this crop and that American farmers in the States bordering on Canada can perhaps be equally successful if they are willing to be equally painstaking.

It is recognized, however, that the crop "is an expensive and precarious one to grow, owing to frequent recurrence of unfavorable seasons and to the extreme care required to grow it successfully."

Professor Stuart states that "the cultural methods employed by Montreal growers are essentially as follows:

> The seed is sown in the greenhouse or hotbed from late February to early April; later they are potted up into 3 or 4 inch pots, and when in danger of suffering for lack of root space and plant food and the weather is favorable they are removed to sash-covered frames, there to remain until they are almost

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[a] Compiled from Vermont Sta. Rpt. 1907, p. 358; Bul. 136.

fully grown. These hotbeds are well constructed, well exposed to the sun, and also protected from cold winds. The frames are often covered with two sets of sash, mats, and board shutters. With such protection, if horse manure is used to generate a sufficient bottom heat and the exposed portions of the frame are banked therewith, the plants may be grown almost as well as in a greenhouse. These frames are movable sections approximately 12 by 6, strong and tight with tie rails for the sash to slide upon.

The soil over which these sections are set is ridged up in beds 12 to 16 feet wide with a 1-foot center elevation. A trench is dug 2 feet wide, 15 to 18 inches deep, and filled almost level with well fermenting manure, and a portion of the surface soil thrown over it, slightly more being drawn in where the plants are to be set. The frames are then set in place and covered with sash, which in turn are further reinforced with mats and wooden shutters, or hay or straw with or without the shutters. A 4 to 6 foot space is allowed between the ends of each section. When the soil over the manure is well warmed up, the warmest portion of some favorable day is selected for planting. Great care is exercised now in transferring the plants from the hotbeds to guard against setbacks from sudden changes of temperature or soil conditions. The coddling process does not cease now. It is simply spread over a greater area and the plants require even closer care than before, for greater attention must be paid to watering, syringing, and ventilation, success at this stage being very largely dependent thereon.

As the fruit attains size, it is usually lifted from the soil by a shingle or flat stone, to avoid loss from cracking, rot, etc. Uniform shape, color, netting, and ripening is secured by turning the fruit every few days. When the runners fairly occupy the inclosed area the frames are raised a few inches. As the season advances more and more air is admitted until, finally, when the melons are almost full grown, the sash and then the frames themselves are entirely removed.

As each fruit sets its shoot is pinched off one or two joints beyond it. A 15 to 20 melon crop is considered sufficient from each 6 by 12 frame. Three or four hills are planted and usually two plants are set per hill.

The melons vary greatly in size. One weighing 44 pounds has been grown. The writer saw one weighing 22 pounds, which had been selected for seed purposes. Their average weight ranges from 8 to 15 pounds, and a dozen averages from 120 to 130 pounds. In exceptional cases some have been shipped weighing 240 pounds per dozen package. The larger melons are apt to be poorer in quality than those weighing 8 to 15 pounds.

Two distinct types exist, a roundish oblate and an oblong, the first slightly deeper ribbed than the latter. These do not seem to be separated by the growers. It is not at all certain that either type is fixed.

A large wicker basket (clothes basket) is commonly employed in shipping to distant markets. They hold a dozen melons, packed in short, fine-stemmed hay, and are shipped without cover, no attempt being made to fasten the melons in place, the express company being held responsible for safe delivery.

Believing that there is no valid reason why American growers, under conditions similar to those of Montreal, should not succeed in producing these melons and that "a crop which may net $1,000 to $2,000 per acre is worth an effort to produce," the Vermont Station has undertaken experiments to determine the conditions and methods necessary to success. The first season's experiments, for various reasons which are explained, were not very successful, but Professor

Stuart states that "the knowledge secured in the handling of the crop justifies the assumption that there is no valid excuse for continuous failure on the part of American growers to produce these melons successfully."

STORAGE OF HUBBARD SQUASH.[a]

In view of the fact that the conditions controlling the losses in storage of vegetables are not very well understood, and that the advisability and profitableness of storage of vegetables for a later market depend largely upon the extent and character of such losses, Prof. W. Stuart, of the Vermont Station, undertook experiments to determine the loss of moisture and from decay sustained in storing Hubbard squash till midwinter, as well as the profitableness of such storage:

> [In these experiments a ton of squash] weighed as taken from the field, was stored on October 3 in a dry and medium warm (50° to 60° F.) room. On December 4 it weighed 1,810 pounds, a moisture loss for two months of 9.5 per cent. On January 4 it weighed 1,657 pounds (sound 1,622, decayed 35), a moisture loss of 8.5 per cent and a decay loss of 1.8 per cent. On February 3, four months from the harvest, the sound squash weighed 1,488 pounds, and the decayed 61 pounds, a moisture loss of 4.5 per cent and a decay loss of 3 per cent. The total moisture loss during four months was 20.8 per cent and that from decay 4.8 per cent; total, 25.6 per cent. * * *
>
> When the squash were put in storage they were wholesaling at 1 cent per pound, late in October at 1.5 cents, 2 cents late in December, and in January, owing to unusual scarcity, at 2.5 to 3 cents. At the conclusion of the trial the 1,488 pounds were sold for $53, an average of over 3½ cents per pound, the net gain by storage being $33 per ton. Market conditions, however, were very unusual. The common price at harvest is $15 to $20 per ton, and does not materially increase until January ($30 to $40), while during February and March they advance to $50. Hence, even under ordinary conditions the increase in price amply offsets losses from moisture, decay, and cost of storage, and leaves a handsome profit.

The conditions tending to minimize losses in storage are stated to be—

(1) The squash should be well matured before harvest.

(2) They should be cut or carefully broken from the vine, leaving the stem attached to the squash.

(3) If possible, they should be placed in small piles to ripen and harden up for two or three days before hauling from the field.

(4) They should be hauled in a spring wagon, the box of which is lined with burlap or other material, to prevent bruising.

(5) The storage room should be dry and moderately warm at least for the first two weeks, to harden up the shells, after which a lower temperature, provided the room is dry, may be maintained.

(6) Finally, squash from harvest to sale should be handled as one would handle eggs. Broken stems and bruised skin are sure to cause decay.

In general, Professor Stuart concludes that "squashes properly grown and handled may be held in storage till midwinter or later with a reasonable assurance that the moisture and decay loss will be amply covered by the increased price received."

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[a] Compiled from Vermont Sta. Rpt. 1907, p. 367; Bul. 136.

There is an additional advantage to be considered, viz, that if the squashes are stored a saving of time may be effected and the hauling to market done at a time when farm work is less urgent.

FIG CULTURE IN THE SOUTH.[a]

The fig tree has been widely though not extensively grown for many years in practically all of the Southern States. Its greatest development is in the Gulf coast region, where it was probably introduced in early times by the French and Spanish. There and along the South Atlantic coast it grows in the open without winter protection, bearing at an early age, and abundantly on soils adapted to its culture. In unusually severe winters the trees may be frozen to the ground; but if the root system has been well established, sprouts will spring up, grow rapidly, and bear in the following year. Under these conditions the tree appears as a large bush. Away from the coastal sections an annual crop is best assured by growing hardy varieties and giving some form of winter protection. The use of the bush or stool form from the start is advisable where there is frequent danger of winterkilling. W. F. Massey, of the North Carolina Station, writes as follows on the winter protection of the fig:

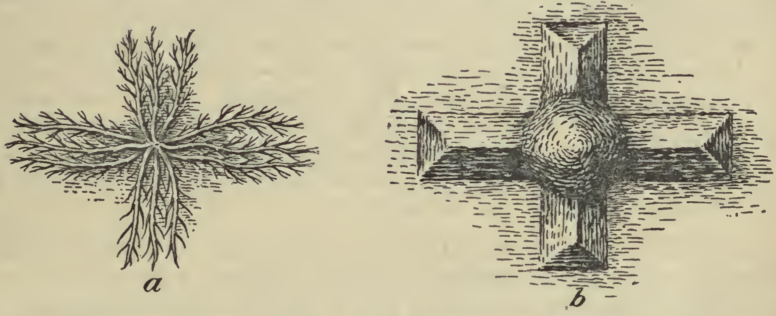

FIG. 2.—Winter protection of fig tree: *a*, Fig tree bent to the ground ready for covering; *b*, fig tree covered with earth.

> On the coast, in the immediate vicinity of salt water, it will need no winter protection. But in the cold western part of the State the method I have found successful in Maryland will do equally well. This is to branch the trees from the ground, and in fall, after the frost has cut the leaves, bend down the branches to the ground and pin them fast, and then pile the earth over them, mounding it over the center and sloping to the outside so as to throw off the water, or gather the limbs like a cross on the ground and cover each bunch separately with a higher mound in the center like a four-pointed star. [Fig. 2.] They will keep perfectly in cold climates in this way.

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[a] Compiled from Alabama College Sta. Bul. 112; Georgia Sta. Bul. 61; North Carolina Sta. Bul. 184; Tex. Sta. Bul. 62; U. S. Dept. Agr., Div. Pomol. Buls. 5, 9. See also Georgia Sta. Bul. 77; Louisiana Sta. Bul. 90.

He found that trees which are buried and covered with earth in the somewhat milder sections are apt to rot in the warm and rainy weather during winter.

> Here the best way possible, though very tedious and troublesome, is to thatch each limb and the stem thickly with broom sedge, wrapped on with cotton twine. This is the best protection I have ever tried; but the bending down and covering with pine boughs usually answers very well. Where the trees are to be bent down and covered, it will be necessary to plant them 20 feet apart each way, in order to give room for the covering. With the earth cover it is more certain to have good crops of figs in a cold climate than here without protection.

Relative to the use of wind-breaks, H. N. Starnes, of the Georgia Station, says:

> A good location for a fig row, on a small scale, will be found upon the south or east margin of a protecting strip of woods, though not so near the trees, of course, as to permit them to rob the figs of their own moisture and plant food. A close board fence or a building makes an excellent wind-break. In lieu of these a hedgerow of Cherokee or Macartney rose, or of Osage orange (where the latter chances to thrive) will serve. A double row of closely set Carolina poplar makes a good substitute on account of its inexpensiveness and rapid growth—for it propagates from cuttings even more readily than the fig itself and grows much faster. As it is deciduous, however, it serves only partially as a protection at the time protection is most needed. Some such evergreen material as Amoor River privet, though not so rapid in growth, is a more perfect wind-break. At the Georgia Experiment Station a row of Deodora cedar is employed for this purpose, but it requires some years to establish it, and it is not to be recommended for general use.

Even farther south, where the tree is grown as a standard and the weather is only severe during occasional winters, some form of protection is advisable for the first three years. After this period the trunk of the fig is less easily injured by cold.

That the fig has not long since been developed as a commercial fruit may be attributed chiefly to the inability thus far to produce a marketable dried fig, the fig of commerce, in the humid southern climate. Moreover, the fresh fruit, which is highly esteemed both by those who grow it and those who have acquired a taste for it, is practically unknown in large commercial centers, being an extremely poor shipper. In a previous bulletin of this Department, F. S. Earle,[a] of the Alabama Station, says, in part, relative to the shipment of fresh figs:

> Fresh figs are not known or appreciated in northern markets, and consequently the demand is too limited to encourage shipments. It seems doubtful if the distant shipment of fresh figs will ever become a profitable business. The fruit is more perishable than any other that is generally marketed. It can be handled only by the most careful and experienced persons, and even then it is not in a condition to show its best quality. Ripening in midsummer, when the northern

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[a] U. S. Dept. Agr., Div. Pomol. Bul. 5.

markets are crowded with many well-known fruits and not being especially attractive to the eye, fresh figs would at best gain favor slowly.

As a domestic fruit, however, the fig is of prime importance, for in addition to its use direct from the tree, it may be either canned or made into jams, jellies, or preserves. It is a wholesome fruit and in the older fig-growing countries is an important food. The fig should never be eaten until thoroughly ripe, since green figs contain an acrid milky juice which not only has a disagreeable flavor but is unhealthful. This trouble disappears when the fruit is ripe.

Relative to the use of the fruit for domestic purposes, Earle says:

> They are eaten fresh from the tree or are served on the table with sugar and cream. They can also be stewed and made into puddings and pies, and when canned or preserved they make an acceptable table delicacy throughout the year. * * *
>
> For canning, figs should be picked when still firm enough to hold their shape. To secure the best results they require the use of more sugar than do some other fruits. If undersweetened they seem tasteless and lacking in quality. The amount of sugar used and the method of procedure vary greatly in different households. A pound of sugar to three or four pounds of fruit would probably suit most tastes, though some prefer the regular "pound for pound" preserve. Ginger root or orange peel is sometimes added to give variety of flavoring, and figs are often made into sweet pickles by adding spices and vinegar. Figs are sometimes peeled before canning, and this is considered to increase their delicacy of flavor. More frequently, however, they are cooked unpeeled and with the stems on, just as they come from the tree. They hold their shape better and look more attractive when treated in this way, and the difference in flavor, if any, is very slight.
>
> Figs are occasionally dried for household use, but as they ripen at the South during the season of frequent summer showers, this is so troublesome that it is not often attempted. A nice product could doubtless be made by use of fruit evaporators, but these are seldom used far south.
>
> In speaking of home uses for the fig, its value as food for pigs and chickens should not be forgotten. Both are very fond of them, and on many places the waste figs form an important item of their midsummer diet. In fact, no cheaper food can be grown for them.

The future commercial development of the fig in the South probably lies in the shipment of selected fresh figs to the larger towns within 200 or 300 miles from the source of production, and in the consumption of the surplus crop and inferior grades by the canneries. Figs have been canned on a small scale for many years in lower Mississippi and Louisiana, and the industry is now being extensively developed along the Texas coast. The canned product is liked by everyone, and the present limited output is disposed of at high prices. According to recent press reports from Texas, several hundred thousand fig trees will be planted by farmers and truck growers in the coast country of that State during the coming winter. The price now paid by the canners for figs is given as $60 a ton, or an average of $150 to $200 an acre for the crop from a 4-year-old orchard.

The fig will grow in a variety of soils and is generally adapted for dooryard and garden conditions, flourishing with little care or attention. There is a scarcity of experience in the South relative to its culture under field conditions. It requires an abundance of plant food, however, and is relatively a surface feeder, the depth of the feeding roots depending to a great extent on the distance to moisture. It reaches its highest development on a fertile, moist, but well-drained loamy soil, containing an abundant supply of lime. In general, lowland soils which do not overflow, or which can be readily drained to a depth of three or more feet, will prove ideal for the fig orchard.

The trees will make satisfactory growth on fertile soils without the use of additional plant food. If either lime, phosphoric acid, or potash is lacking, it should be liberally supplied, especially when the trees reach the bearing age. Starnes, of the Georgia Station, says:

> A good annual mulch of well-rotted lot manure is the best fertilizer that can be given the fig—supplemented when the trees are of bearing age and the growth of wood is lusty and vigorous by the addition of phosphoric acid and potash. * * * Five pounds of acid phosphate and 2 pounds of muriate of potash per tree, broadcast, would not be too much. Eight pounds of kainit or a peck or so of hardwood ashes may be substituted for the muriate of potash if desired. * * * From 5 to 6 pounds per tree of air-slaked lime would prove profitable; but it should be applied separately and never in conjunction or mixed with either the lot manure or the commercial fertilizer.

On the other hand, as R. H. Price and E. A. White pointed out in a bulletin of the Texas Station, an excessive use of stable manure and other nitrogenous fertilizers should be avoided, as they stimulate a luxuriant growth of foliage and wood at the expense of the fruit.

The fig grows readily and bears early from cuttings. This is the usual method of propagation in the South. Quoting from the above-mentioned Texas bulletin:

> The cuttings are taken during the winter from wood grown the previous season. It is essential that the wood be of the right degree of maturity or the rooting process will not be successful. * * * When the wood is cut the surface of the wound should be moist and covered with small drops of milky white sap. The length of the cuttings depends upon the moisture of the soil. If the soil is quite moist they may be as short as from 4 to 8 inches, but if the surface soil be dry they must be long enough to extend down into the moisture, if it be 2 or more feet. Cuts should be made just at the joint, at both base and top. This is important, for the fig has a solid stem at the joint, but has a pith in the center of the stem between the joints which quickly decays, and the wood will always die back to the first joint. If decay once starts it is very likely to extend beyond the first joint and destroy the cuttings. * * * Insert the cuttings to the top bud in rich, moist, well-drained land. It is essential that the soil be well packed at the base of the cutting, for if an air space be left the cutting will likely shrivel without rooting.

Where the climate is too severe to plant the cuttings immediately in the open, they may be bundled and buried until spring, as with grape cuttings. It is frequently advised that the cuttings be planted in the site the tree is to occupy permanently, as the fig is often severely set back by transplanting. When transplanted to the orchard from the nursery row the roots should be carefully protected from drying out. It is well to plant two or more cuttings in each tree position. This will tend to lessen vacancies in the orchard, and the excess number can be taken out later. Planting distances differ with the varieties grown, and with varying soil and climatic conditions. Available figures indicate that 12 by 16 feet, with every other row removed when the trees begin to crowd, will be sufficient for most varieties. This would leave the permanent planting 16 by 24 feet.

No general system of orchard cultivation has been worked out for the fig in the South. Some advocate as little culture as possible, since the fig is a shallow feeder. If the preparatory plowing as well as subsequent cultivations are made as deep as is consistent with the nature of the soil in each case, the roots will be encouraged to feed more deeply and the danger from mechanical injury confined largely to thin soils.

On the thin soils which abound in many parts of the Southeast it is difficult to cultivate without doing serious injury to the roots. Earle suggests "mulching heavily near the tree with any available material that will hold moisture and keep down the weeds. * * * The middle of the rows can be kept clean by a shallow plowing and harrowing without disturbing the mulch and without injury to the roots protected by it." When the weeds and grass are not allowed to get too big a start, the small-toothed cultivator or an acme harrow will prove efficient tools for surface culture. The practice at the Texas Station, where the soil is a heavy clay loam, has been "to disk the orchard lightly at frequent intervals during the spring and early summer to keep down the weeds and conserve the moisture." This method proved satisfactory for tree growth.

Frequent pruning is considered detrimental to the fig tree. The quality of the fruit is not improved and the quantity is usually decreased thereby. The general advice is given to prune only sufficiently to shape the young tree, to remove all injured wood, and to thin out the head of the tree to admit air and sunlight. All cuts should be made at a joint, and as a rule the branches or canes should be completely removed, rather than stubbed back. When a branch is only partially removed, the numerous shoots forming below the cut make the head irregular in shape and necessitate more pruning later on. Where the fig is to be grown as a standard tree, pinching back the leader during the growing season will hasten the development of the lateral branches. The use of low branching standards to shade the soil is advisable in sections where long-continued droughts occur. The same effect may be produced by starting two or three main stems from the ground. The latter form of tree is less liable to break down under a heavy crop. In colder sections, where the bush or stool form is grown, pruning should be limited chiefly to the removal of weak or injured canes.

The Celeste, Brown Turkey, and Brunswick appear to be the three most widely grown general-purpose varieties. The prospective grower, however, will be assisted in the choice of varieties for different purposes and sections by consulting "Varieties of Fruits Recommended for Planting."[a] He should also seek the advice of the State experiment stations and of local practical growers, since varietal names are not the same in all sections and, furthermore, well-known varieties are held in different esteem in different sections. The Celestial or Celeste is preferred for canning in the northern Gulf coast region, while a variety locally known as the Magnolia but said to be identical with the Brunswick grown at the Texas Station, is largely used for canning in the coast region of that State.

The fig has thus far been relatively free from insect pests and fungus diseases in the South. Relative to maladies in Georgia, Starnes writes, "its worst enemies appear to be wet weather and fruit depredators such as birds, junebugs, wasps, and other insects." The birds, he says, "pay their score most royally by the destruction they visit upon insects injurious to other crops. * * * Fungus affections are fortunately few and do not affect a great amount of damage, if we except the operation of the ferment producing the fig 'sour,' which is almost always a concomitant of prolonged wet weather. A leaf rust sometimes prematurely defoliates the trees, but does not do much harm." Although the cotton root-rot fungus (*Ozonium auricomum*) is said to occur on the fig, no particular damage from this source has been thus far reported.

The nematode *Heterodera radicicola*, a minute worm which causes the disease known as root knot by infesting the soft fibrous roots, thrives best in moist sandy soils, and is more or less troublesome throughout the entire coast region. Starnes advises the use of the mattock as the best remedy for this trouble. "Figs develop so rapidly that a vacancy is soon filled, and the chance of the malady, whatever it may be, involving the rest of the plat, is thereby reduced. Yet it is well to be first assured that some actively injurious agency and not deficient nourishment is the operating cause. Therefore on noting any apparent weakness or deterioration the sickly individual should receive a top-dressing of nitrate of soda. If this fails to renew its vigor and the tree still maintains an abnormal appearance, grub it out and renew."

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[a] U. S. Dept. Agr., Farmers' Bul. 208.

The remedy advised by J. C. Neal in a previous bulletin of this Department,[a] which consists of draining the land thoroughly and applying tobacco dust mixed with unleached ashes or lime, is reported as having been tried with success in some sections of the Texas coast country. The orchard should be planted on land known to be free from the pest, and truck crops should not be grown between the rows, as they are nearly all subject to root knot.

The fig-tree borer (*Ptychodes vittatus*) has caused some trouble in certain parts of Louisiana and Mississippi. Of this pest W. C. Stubbs, of the Louisiana Stations, says:

> The damage done in Louisiana is to a large extent conjectural. In our groves we have lost several trees temporarily, all being bored into by this borer. They, however, start up again quickly from the roots and soon replace the injured trees. We have had no remedy against this invasion except to dig it out while very young with a penknife. We have tried various insecticides without apparent results.

During long-continued rainy weather or in wet soils the crop often sours on the tree. Aside from attention to drainage and using care not to overirrigate, little can be done for this trouble.

The fig should be thoroughly ripe when picked for immediate home consumption, and only a trifle green when picked for shipment. Quoting from a bulletin of the Georgia Station—

> It must be picked fully ripe to be worth eating and can not be gathered prematurely, like the peach or plum. But a day's wilt somewhat improves its quality and increases the sugar content, provided it is carefully handled. After twenty-four hours, however, the danger line is reached and fermentation is imminent. It must therefore be handled rapidly as well as tenderly. * * * Gathering the fig is a difficult and clumsy process when the fruit can not be reached by hand from the ground, on account of its very soft character. It is almost as troublesome to gather safely as is the persimmon, and the slightest fall ruins it. * * * Yet the fig tree, while possessing brittle wood, and therefore not to be climbed, is fortunately not lofty, as a rule, and its fruit is readily reached by the help of a stepladder. From the ground the fruit may be conveniently reached by means of a home-made "gatherer" or "fig cup," constructed very simply by tacking a baking-powder can to a pole of any desired length, first filing a portion of the rim of the can to a cutting edge. For horizontal work—reaching out from the ladder for distant fruit—a modification may be made by tacking the can to a pole at a right angle to it, like a dip net.
>
> Shipping must be effected in either berry cups or extremely shallow trays—preferably the former. The standard 24-quart strawberry crate is the best package to use. Only nearby markets are practicable.

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[a] U. S. Dept. Agr., Div. Ent. Bul. 20.

Sufficient has been said in this article to indicate in a general way the possibilities and cultural requirements of the fig for the South. It should be borne in mind, however, that there are as yet no extensive fig orchards in that region and that every such planting will be, to a large extent, an experiment in which the individual planter must work out questions pertaining to soil, climate, and varieties as well as many of the details of cultivation. In general it may be said that, other conditions being equal, the farther South the fig is grown the greater will be the chance of success.

PURE CULTURES IN MUSHROOM GROWING.[a]

As pointed out in a previous Farmers' Bulletin,[b] the use of pure or tissue cultures for mushrooms has developed as a result of investigations of this Department. There are now several commercial kinds of these cultures. The use of pure cultures in this case, as in case of butter making, cheese making, and other processes, results in greater uniformity and certainty of the product.

F. A. Waugh, of the Massachusetts Station, compared pure-culture spawn with English and French spawn in mushroom culture during two years under ordinary conditions and found that pure-culture spawn is, as a rule, very much better than either English or French spawn, but that there are important points of difference between the commercial pure-culture varieties. These differences consist in color, flavor, form, and, above all else, in productivity.

In all of the experiments pure cultures gave larger yields than either the English or French spawn.

"It seems to be one of the chief advantages of the new method of growing mushroom spawn from pure culture that it nearly always gives fresher and more vigorous spawn. The product is nearly always more uniform and of higher quality; but, while this advantage is important, it is not so great as the one already mentioned."

As a general result of his experience in mushroom culture, Professor Waugh expresses the opinion "that mushrooms can often be grown profitably as a catch crop in cellars or under greenhouse benches where conditions are favorable. The most important favorable condition to be considered is a cheap and reliable supply of fresh horse manure. It is quite plain, however, from our experience, that the stories of sudden wealth accumulating from mushroom growing are mostly fictitious."

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[a] Compiled from Massachusetts Sta. Rpt. 1906, p. 208.

[b] U. S. Dept. Agr., Farmers' Bul. 204.

PRESERVING WILD MUSHROOMS.[a]

In a bulletin of the Oregon Station, E. F. Pernot urges that "while the growing of mushrooms is an easy matter, requiring but little time and attention, we must not neglect to utilize the abundance which grow wild, requiring only the effort of gathering and preserving them for future use." He states that mushrooms "may be canned as easily as fruit and much easier than some vegetables."

The buttons ranging in size from the smallest to those with the cup breaking from the stem are the most desirable for canning, as they remain firm and white after being heated. When sufficient buttons are gathered they are cleaned by peeling, or by wiping with a cloth, removing any soiled spots or earth which may have adhered to them; the stems are cut off, leaving from one-half to 1 inch remaining attached to the cap. They may then be placed in a granite-iron kettle and heated without water until shrinkage ceases, after which they are placed in cans that have previously been cleaned and scalded, and the liquor poured over them, completely filling the can.

If glass cans are used, after filling they are placed in any kind of vessel provided with a cover and containing a small amount of hot water. A sheet of asbestos or a thin layer of excelsior is placed in the boiler to prevent the glass coming in contact with the bottom. The caps are placed loosely on the cans and with steamer cover in place allow the water to simmer for half an hour. Upon removing the cover from the steamer, immediately screw the can covers down as tightly as possible, then place the cans away to cool, upside down, in order to detect any leak. If all are perfectly sealed, allow them to stand until the next day at the same time, when they are again heated in the same manner, except that the time must be prolonged to one hour, because the contents of the cans are cold. Repeat this operation again the third day, which will complete the sterilization, and the mushrooms will be found to be as nearly like the fresh article as it is possible to have them. They keep well and do not deteriorate in consistency nor flavor. The cans must be kept sealed throughout the operation.

If desired the mushrooms may be stewed in milk, or prepared in any manner for the table and then canned in the manner described. When the can is opened they require heating only before serving.

When tin cans are used they are handled in the same manner as the glass ones, with the exception of soldering the lid as soon as the can is filled, leaving the vent open until after heating the first time, when it is immediately closed with a drop of solder while can is hot, thus forming a partial vacuum that takes up the expansion caused by subsequent heatings.

This method of sterilizing kills the vegetative germ cell at the first heating, and the intermission between heatings induces the spores to germinate into cells, thus enabling a much lower temperature to be used than what would be required to kill the spores.

If it is desirable to sterilize the mushrooms at one operation, the cans should be filled as already described and, after sealing, heated to a temperature of 240° F. for thirty minutes. This, however, requires a steam chest capable of withstanding a pressure of over 15 pounds to the square inch and is not commonly found in the home; besides the flavor and texture of the article being canned is materially impaired by this high temperature, and glass cans can not be used.

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[a] Compiled from Oregon Sta. Bul. 98.

When the older mushrooms are used for canning they reduce very much in bulk, becoming mushy and turn black after being heated. They do not present such a tempting appearance, but the flavor is not impaired.

A good use to make of the older mushrooms is to dry them. This may be done after they have been peeled or cleaned by placing them upon boards, or drying racks, only one deep, and exposing them to the sun and air. Beginning with the cap side down they should be turned over every day and must not be left out during the night, as they absorb moisture very rapidly. They may also be dried upon wooden trays in a warm room. When dried by either method until they feel dry to the touch, finish them in the oven and while brittle grind them into a fine powder with a spice mill, or even a coffee mill will answer the purpose. The powder should at once be placed into well-stoppered, dry bottles or fruit jars well sealed and kept in a warm, dry place. Mushrooms that are wet can not be successfully dried. The best are those which grow and are gathered dry.

Mushroom powder keeps very well and it is one of the most delicious flavoring condiments of the kitchen. If milk is used in making meat gravy or other dishes, the flavor is much more pronounced.

The mushrooms may also be dried in the manner described and used whole by first soaking them before preparing the various dishes; they are practically the same as fresh ones with the exception of being somewhat tough. The flavor is fully as strong as in fresh ones.

Mushrooms in various stages of development will be secured at each gathering, but these may all be utilized. "The buttons of various sizes may be canned, those with caps fully opened and firm may be dried and used whole or made into powder, while the older ones, those which have been broken, and stems, are made into catsup."

The author recommends the following recipe for making catsup as one which preserves the flavor and keeps well after the bottles are opened:

Take all the mushrooms that can not be used for canning and drying, or all good ones, if desired, place them in an earthen jar and sprinkle salt over them, stirring so that all receive the salt; allow them to stand for twelve hours; then mash and strain through a cloth. For every quart of the liquid add one-half teaspoonful ground ginger and one-half teaspoonful black pepper. Boil in a granite iron kettle until it is reduced not less than one-third. Prepare the bottles by cleaning and thoroughly boiling them and their corks, then fill to the neck with hot catsup, cork tightly and when the cork has dried and before they are cold, dip the cork and about half an inch of the bottle neck into hot canning wax, previously melted in a cup or can. It is advisable to use rather small-sized bottles so that the contents may be used before remaining open too long.

Attention is called to the fact that in "some seasons, and under certain weather conditions, mushrooms are infested with insect larvæ, unfitting them for use in any form. They are most always found where the cap joins the stem and can easily be seen by breaking off the stem where they are localized at that point. In later stages they will be found to infest the cap and stem. The buttons are less likely to have them than the more mature fungus."

The variety of mushroom referred to in the above directions is the common pink-gilled field mushroom (*Agaricus campestris*). This variety the author states "may readily be recognized by a child without fear of obtaining a poisonous one."

> It first appears in the form of a white ball, or button, connected by a stem which extends into the earth; as it increases in size the cap expands from the lower side and a veil which connects it with the stem is torn, leaving a ragged membrane adhering to the stem. The cap is covered with a rather tough skin which may be peeled off quite readily. The gills vary in color from a delicate pink in the young growth, to a deep brown as they mature; they are not attached to the stem. The stem is white, smooth, and brittle, with the lower end somewhat pointed and blunt. When young it is as good to eat as the cap. No mushrooms having a bulb or cup on the lower end of the stem should be eaten.

The food value of mushrooms has been discussed in a previous bulletin of this series.[a]

COOKING BEANS AND OTHER VEGETABLES.[b]

In connection with the home economics work at the Ontario Agricultural College, Miss M. U. Watson reports the results of tests in cooking dried beans and vegetables.

Beans.—Four samples of beans, each lot weighing 8 ounces, were soaked in lime water containing 0.03 per cent lime, in hard water from the local supply, in the same water softened by boiling and also by the use of bicarbonate of soda, in the proportion of 1 teaspoonful to a gallon, the work being undertaken with a view to ascertaining the effects of hard and soft water upon the quantity of cooked beans. After twelve hours the samples soaked in softened water each weighed 12.75 ounces, those soaked in lime water and hard water 12.25 and 12.5 ounces, respectively, and it was found that the smallest amount of material, 1.8 grams in round numbers, had been removed from the beans soaked in water softened by boiling, and the largest amount, 2.5 grams, in the beans soaked in water softened with bicarbonate of soda.

Each lot of beans was then cooked for three hours in a double boiler and showed some differences in quality and appearance. The smallest amount of protein removed, 3.6 grams, was noted with the beans which had been soaked in water softened by boiling, and the largest amount, 5.4 grams, in those which had been soaked in water containing bicarbonate of soda.

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[a] U. S. Dept. Agr., Farmers' Bul. 79, p. 18.

[b] Compiled from Ann. Rpt. Ontario Agr. Col. and Expt. Farm, 33 (1907), p. 240.

In general, the beans soaked in softened water absorbed more water than the others and consequently increased more in weight. Three hours' cooking at the simmering point did not soften and disintegrate the cellulose of beans cooked in hard water, and such beans the author considers neither palatable nor digestible.

The harder the water in which beans are cooked for a given length of time, the more unpalatable and indigestible the beans, and the more protein lost in cooking.

Beans cooked in water softened by boiling have, the author states, a much more appetizing appearance than those cooked in water softened by baking soda. They keep their shape better and are only very slightly colored yellow. They are also more mealy and "would therefore be most digestible, as the saliva could most easily mix with the particles of the bean."

The author therefore considers that the beans cooked in water softened by boiling were the most palatable and nutritious, while at the same time they lost least of their nutritive constituents in soaking and cooking.

"As seen in this experiment, the best results are obtained by cooking beans in water softened by boiling."

Strong-smelling vegetables.—In tests which were undertaken to learn the best methods of cooking strong-smelling vegetables to secure a palatable product and to avoid odors in the house, half-pound samples of cabbage and onions were cooked in salted and unsalted water in covered and uncovered pots. It was found that when the vegetables were cooked by simmering in a close-covered pot less steam was formed than when they were boiled vigorously, and of this steam little escaped into the room, and consequently there was less odor noticeable than under the other experimental conditions. Vegetables cooked by simmering in a covered pot had also a much better color than the others. The best results were obtained when salt was added before cooking. If added afterwards the flavor was more insipid. More substance was dissolved out when salt water was used, but as the author notes, "we do not depend on cabbage or onions to give us food substance, so the little loss is not of much importance."

The general conclusion reached is that "the best method of cooking strong-smelling vegetables is to simmer in a covered pot in salted

A MODEL KITCHEN.[a]

At a housekeepers' conference held at the Agricultural College of the University of Missouri, the experiment station exhibited a full-sized model of a convenient farm kitchen. As pointed out by Dr. Edna D. Day, of the home economics department, in her account of this project, it is essential that the necessary routine work of the home should be made easy if the home maker is to have time, energy, and enthusiasm for her home life, and there is perhaps no place in the home where more unnecessary time and energy are expended than in the ordinary kitchen, owing to faulty planning and inconvenient construction and furnishing. In this model kitchen an effort has been made to secure economy in steps taken and in the time and energy required for housework. The diagram (fig. 3) shows the general plan of the kitchen, its position in relation to the pantry, dining room, and other rooms, and the location of the range and other kitchen furniture.

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[a] Compiled from Missouri Sta. Cir. Inform. 30.

A floor covering of oilcloth or linoleum is suggested as desirable, since it can be kept clean easily by mopping, and it does not require hand and knee work with a scrubbing brush. For best wear the more expensive sort is preferable, but even a cheap floor covering, which needs very frequent replacing, is, in Miss Day's opinion, preferable to a wood flooring, which needs more scrubbing. "An oiled hard-wood floor is easily cleaned, but dark and unattractive. Tiling is clean, but harder for the feet than linoleum." A sanitary wall covering in imitation of tiling is recommended, which is applied like ordinary wall paper, and which is comparatively cheap, easily cleaned, and attractive. It must be carefully hung so that there may be no cracks or other hiding places for vermin. Metal tiling is perhaps more sanitary, but is also more expensive. It is, however, cheaper than true tiling and perhaps as satisfactory.

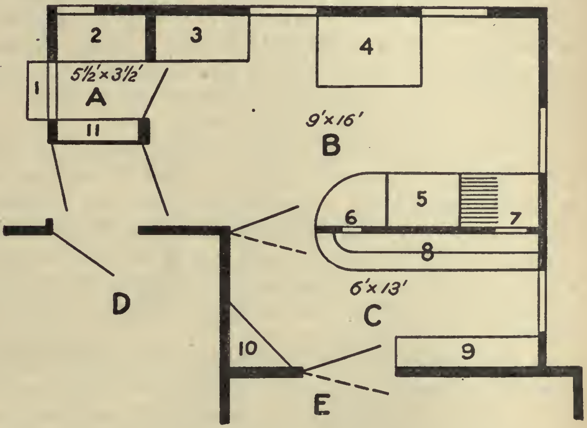

FIG. 3.—Plan of a model kitchen (scale: ⅛ in. is 1 ft.): A, Cold pantry; B, kitchen; C, butler's pantry; D, back hall; E, dining room. 1. Window box to be used to keep food material in cold weather. 2. Refrigerator with outside door for icing. 3. Kitchen cabinet. 4. Range. 5. Sink with shelves and draining board on either side. 6. Door for passage of soiled dishes from pantry into kitchen. 7. Door for clean dishes to be passed back. 8. Shelves in pantry. 9 and 10. Shelves with glass doors. 11. Shelves in cold pantry.

In this model kitchen a model kitchen cabinet, which provides many conveniences and has the advantage of grouping working materials at hand where they are needed, is placed where there is good light, next to the stove, on the one hand, and to the cold pantry, on the other, with the sink at the back. The stove is also placed where light is abundant.

The easily cleaned refrigerator, in the conveniently placed cold pantry, has an ice door that can be reached from the outside, saving the kitchen floor the dripping and footprints which generally mark the iceman's path. Outside of the pantry window is a box in which food can be kept cold many months in the year without the use of ice. If well finished and painted the color of the house on the outside, this need not mar the exterior appearance of the house. The shelves in the pantry afford room for storing food materials.

The small table on rollers can be moved into the cold pantry for pastry work, when the kitchen is too hot. It can conveniently find place between the kitchen cabinet and stove when frying or other cooking makes a table at that point convenient. In kitchens where sink and china closet are far apart, such a table saves many steps at dish-washing time. In this kitchen the lowest shelf of the china pantry is convenient for the reception of dirty dishes from the dining-room table. Here they can be scraped and piled and passed through the window on to the shelf at the right of the sink.

A window at the end of the drain board gives light for the dish washing and allows, if the view be good, a chance for inspiration during the mechanical work of dish wiping. The window into the cupboard over the drain board may be made small, allowing simply for the passage inward of the piles of clean dishes, or may be made large enough to give access to the back of all the shelves in that part of the pantry, allowing each dish to go directly from the dish towel to its place on the pantry shelf. The opening may be closed with glass or wooden doors.

At the farther end of the kitchen is a place for the ironing board near to both stove and windows, but entirely out of the way of other workers in the room. It may be hinged to the wall at one end and folded up into a wall cabinet when not in use. Inclosed shelves below may give place for the irons, holders, and wax. The heights of the ironing board, sink, and table should be suitable to the height of the worker. A high stool can be used to advantage at the sink and kitchen cabinet. Every kitchen should have at least one comfortable chair. Since at best many hours daily must be spent in the kitchen, its arrangements and equipments should be such as to make the work there as easy and as attractive as possible.

Some of the visitors said that the kitchen was too small for a farm, but those who had had experience both in a small, conveniently arranged kitchen and in a large one in which miles must be walked in doing the ordinary day's work, were in favor of the compact arrangement.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 343.

THE CULTIVATION OF TOBACCO IN KENTUCKY AND TENNESSEE.

BY

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1909.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., November 5, 1908.

Sir: I have the honor to transmit herewith a paper entitled "The Cultivation of Tobacco in Kentucky and Tennessee," by Messrs. W. H. Scherffius, Collaborator, and H. Woosley and C. A. Mahan, Special Agents, Tobacco Investigations. I recommend that this manuscript be published as a Farmers' Bulletin.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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THE CULTIVATION OF TOBACCO IN KENTUCKY AND TENNESSEE.

INTRODUCTION.

Tobacco belongs to the order of plants commonly known as the nightshade family. Its generic name, "Nicotiana," was given to it in honor of Jean Nicot, French ambassador to Portugal in 1660. When, two years before this, specimens of tobacco had been brought from Mexico to Spain, Nicot secured some of the seeds and sent them to Paris.

There are fifty or more species of the genus Nicotiana, though few of them enter into the commerce of the world. The species grown in the Ohio Valley, the one of chief importance, is *Nicotiana tabacum*. The aborigines of America grew tobacco long before the advent of the white man. The French explorers Marquette and La Salle found it in cultivation and use by the Indians along the Mississippi and Ohio rivers and their tributaries as early as 1669 and 1673. In 1750, nearly one hundred years later, Capt. Christopher Gist, an agent for the "Ohio Company," came down the Ohio River and found tobacco being grown by a tribe of Indians at Shawneestown, the present site of Portsmouth, Ohio. During this same time tobacco was being grown by the Shawnees at the present site of Indian Fields, Ky., in Clark County.

In 1775 white pioneers migrating westward from Virginia and North Carolina made a permanent settlement at Boonsboro, Ky. Being familiar with the handling of tobacco and its value, they immediately began growing it along with other crops. Soon after the founding of Boonsboro the price of tobacco increased rapidly, which encouraged the tobacco farmers of Virginia and North Carolina to migrate into this new and fertile territory. As early as 1792, when Kentucky was admitted into the Union, settlements were being established throughout the States bordering on the Ohio River. Following the custom in Virginia, tobacco became a medium of exchange. After home consumption had been supplied the surplus was shipped down the Mississippi to New Orleans for exportation. The French settlers of the Illinois country had there been following this method of disposing of their surplus for nearly a quarter of a century. As the population increased, the demands of the home market likewise increased, and in a short while establishments were located at Lexington, Ky., and other points for the purpose of manufacturing plug and twist tobaccos for home consumption. A steadily increasing demand on the home market developed, while the export business dwindled to nothing and was not revived until after the close of the civil war.

In 1866 a very important discovery pertaining to tobacco was made by Mr. George Webb, a farmer living in Brown County, Ohio. He noticed in his field of tobacco some plants which were light green in color, with cream-colored midribs and stalks. The seed which had produced this type was furnished to Mr. Webb by the United States Commissioner of Patents, in whose office at that time the distribution of seeds under Government auspices was conducted, and these plants were probably mutations, or sports, due to the effect of change in soil or climatic conditions. They were so different in appearance from those which produced red tobacco that Mr. Webb carefully preserved them and saved the seed. It was noticed that tobacco from this selection of seed gave a brighter cured product than the original red tobacco from which it was obtained. The new type of tobacco gained favor rapidly on account of its mild quality and bright silky appearance, and its cultivation soon spread over what is known as the White Burley district. This type now supplies the market with chewing, cigarette, pipe, and cigar tobaccos, but the greater part of it is manufactured into chewing tobacco.

The dark-tobacco district, including western Kentucky, part of western Tennessee, a small area of Missouri, southern Illinois, and southwestern Indiana, produces a dark, heavy type, which is principally exported to European countries.

In view of the fact that Kentucky and the bordering States produce 376,647,000 pounds annually—one-sixth of the total production of the world, and more than one-half of the production of the entire United States—of a quality of tobacco which is peculiarly confined on account of soil and climatic conditions to this area, we may expect that a great part of the world will continue to look to this western section for supplies for its consumption.

Much has been written in recent years in regard to the improvement of the tobacco plant by breeding and seed selection, but little reference has been made to the actual field operations employed in the cultivation of the crop in this western section. It is the object of this bulletin to present the best methods of cultivation now in use, with detailed descriptions of the principal operations employed.

THE PLANT BED FOR TOBACCO.

The plant bed should be located on some well-drained spot, with southern and eastern exposure if possible. This gives the maximum amount of sunshine and a protection against the cold northern and western winds. It is a common practice to select a place in the woods where the soil is loose, friable, and rich in humus, but in sections where wooded tracts are scarce plots covered with brier patches or a heavy growth of shrubbery often found in abandoned fields make desirable locations. A good substitute for virgin soil and one often used in the White Burley district is a field bearing a heavy growth of bluegrass sod, but cultivated lands do not give as good results and should not be used if it can be avoided. A few successful farmers use the same bed for several consecutive years. In such cases an application of barnyard manure and tobacco stems or stalks should be made in the fall. During the winter the soluble elements are removed by leaching and carried into the soil. When the time for burning has arrived, the manure and stems are raked off and heaps of waste wood and brush are piled on the bed and burned.

In case the barnyard manure and tobacco stems or stalks have not been previously applied, an application of high-grade commercial fertilizer, one containing, say, 10 per cent of potash, 4 per cent of nitrogen, and 10 per cent of phosphoric acid, all in an available form, will give good results. It should be applied at the rate of 100 pounds for every 1,500 square yards. Commercial fertilizers are not extensively used. The farmers as a rule depend entirely upon the natural fertility of the soil to produce the desired growth in the young plants before transplanting.

The preparation of the seed bed is of such importance that neither time nor labor should be spared in making all of the conditions first class. Neglect to have plenty of good plants necessitates the curtailment of a crop and may result in its complete failure.

The main object in burning the bed, so far as the writers can see, is the destruction of weed seeds which would otherwise produce weeds to interfere with the growth of the young plants. Most of the weed seeds are lodged in the upper 2 inches of the soil, and their vitality is readily destroyed by burning or heating the bed. Some mineral plant foods, such as potash salts, are rendered more available by burning, which adds to the store of available potash in soils. On the other hand, organic matter is largely destroyed by the burning, which is detrimental to the extent that it liberates some of the nitrogen, thus reducing the amount available for plant food, and also reduces the moisture-holding capacity of the soil by destroying a part of the humus.

The scarcity of wood has caused the advent of a tobacco bed burner, which is a movable device especially designed for burning plant beds. The furnace is 3 feet wide and 9 feet long and is arranged with a pan on which the soil is placed and roasted for about an hour. The fire is fed under one end, similar to the way an evaporating pan is heated in making molasses. A block of soil 9 feet long, 3 feet wide, and 2 inches deep alongside of the furnace is shoveled into the hopper. During the heating it should be turned over two or three times with a long-handled shovel. The roasted soil is then shoveled out of the hopper back into the hole from which it was taken. This same operation is repeated with the soil on the other side of the furnace. By the time this second block of soil is roasted the soil covered by the furnace is likewise sufficiently heated. Hence, at each setting, a space of 9 feet by 9 feet is burned. Reference to the illustration (fig. 1) will give a good idea of how the furnace is constructed.

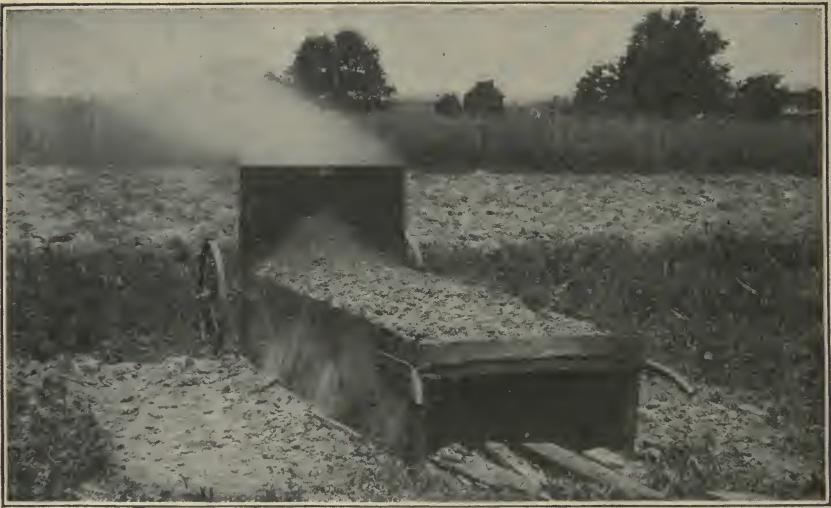

Fig. 1.—Tobacco bed burner in operation.

Under ordinary circumstances, 45 to 50 square yards of ground can be burned with this furnace in a day. If a stiff wet clay is being dealt with, more time will be consumed in burning and the area covered in a day will be correspondingly lessened. The principal advantages of the furnace are that the ground can be burned while wet without fear of baking except in the area directly beneath the furnace, a more uniform and thorough burning may be secured, more weed seeds are destroyed, and less wood is required. The furnace is made of sheet iron throughout, costs about $35, and is serviceable for several years. This type of furnace has been in use for four or five years, but has not come into use by a majority of the farmers.

The bed may be burned at any time from November to the last of March. A few farmers burn in the fall, a desirable practice in many respects. The weed seeds are then on top of the ground and the soil is likely to contain less moisture, so that much less fuel is required. Most beds are burned by the open-fire method during February and March, as weather conditions are favorable at that time. It is preferable to have the soil as dry as possible in order to avoid baking in burning and to economize time and fuel. If much water has to be evaporated from the soil unnecessary delay is experienced.

A few farmers sterilize their beds with steam.[a] In this case a steam box of the desired dimensions is constructed and placed over the selected spot, a boiler for supplying the steam being used. Sufficient pressure to destroy all weed seeds can be easily maintained. Beginning with 120 pounds of steam it will be reduced to about 90 pounds in a single operation. While this method of sterilizing has not come into general use, those who have tried it pronounce it a complete success. After the bed is sterilized it is thoroughly worked to a depth of from 2 to 4 inches with hoes, rakes, and disk plows or harrows.

It is a common practice to raise the level of the bed a little above the surrounding surface by bedding; also to leave 12-inch valleys around the bed and have them cross the bed at intervals of from 6 to 12 feet. This gives good surface drainage. After the soil is thoroughly prepared, the seed is sown; in the Burley district at the rate of 1 teaspoonful to every 200 square feet; in the dark district at the rate of 1 teaspoonful to every 300 square feet. There is no good reason for this difference; custom has established these measures.

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[a] The method of steam sterilization of tobacco seed beds in the Connecticut Valley, devised by Mr. A. D. Shamel, of the Bureau of Plant Industry, and now in practical and successful use in that region, is as follows: A steam pan is made of sheet iron, 10 feet long, 6 feet wide, and 6 inches deep. Attachments are made which provide for the introduction of steam into this pan and for the connection of the steam hose or pipe running from the steam boiler to the pan. This steam hose should be at least 1 inch in diameter and 50 feet long, so as to permit the supply of an abundance of steam and in order that the box may be moved without moving the steam boiler.

The soil for the seed bed is fertilized and prepared in the same manner as for the sowing of the seed. The pan is turned over a section of this prepared soil and care taken that the edges of the pan sink into the loose soil, so as to prevent the loss of steam under the edges of the pan.

The steam is now turned into the pan, and on being confined under the pan under pressure it rapidly heats the soil to the desired depth. A strong pressure should be maintained in the steam boiler and a full supply turned into the pan.

In the beginning the temperature of the heated soil should be frequently determined. It is desirable to heat the soil to 175° F. to a depth of at least 4 inches and to maintain this temperature for about one hour. This treatment destroys the weed seeds and diseases in this soil and improves the condition of the seed-bed soil for the growth of tobacco seedlings.

About 600 square feet of seed-bed surface can be treated in one day according to this plan. The tobacco seed should be sowed the following day and lightly raked in.

In view of the fact that the seeds are so small, a sufficient quantity to sow a bed is mixed with one-half gallon of fertilizer, ashes, dirt, or corn meal, so that the sower may secure a more even distribution of them. They may be settled into the ground by rolling, trampling, or lightly raking over the bed.

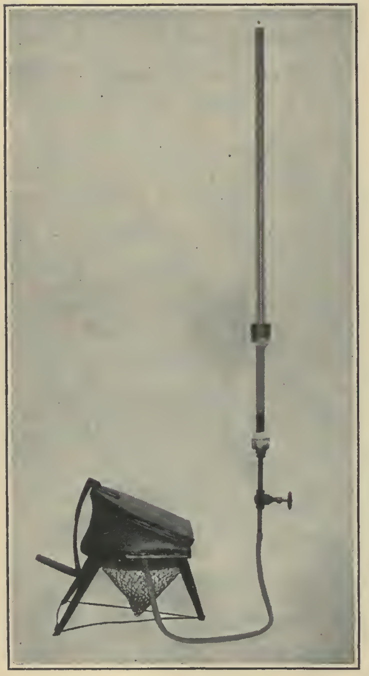

FIG. 2.—Tobacco seed grader for separating heavy from light seed, devised by Mr. A. D. Shamel, of the Bureau of Plant Industry.

During the winter months before sowing time the seed should be graded in a tobacco seed separator, like that shown in figure 2, which will remove all the light and immature seeds. The importance of good seed in every crop has been demonstrated so often that every farmer should know that it pays him well to sow only the best. It has been demonstrated here and elsewhere that the lack of uniformity in our tobacco fields is largely due to poor seed. (See fig. 3.)

Sowing should not be made later than April 1. Beds sown from January to April produce plants for setting by May 15 to June 10, which is usually the best time. If the weather conditions are such that sowing can not take place until late, the seeds can be partly germinated by mixing the quantity to be sown with sand about ten days previous to sowing. The sand should be kept moistened and in a warm place. If the mixture is kept in a very favorable situation, it is not desirable to extend the soaking period more than ten days. The tobacco seed coat is comparatively thick and hard to break, however, and usually three weeks are required before complete germination takes place.

CARE OF THE BED.

To secure rapid growth of the young plants and to afford protection from frosts it is necessary to use a covering, which is usually made of ordinary cheese cloth. The bed is boxed up by using 1-inch boards placed on edge, extending all around the bed. Wires are stretched across or pegs or wickets are put down a few feet apart on the bed and arranged to hold the canvas a few inches from the ground. The widths of canvas are sewed together to fit the bed, and are stretched over the bed and tacked to the surrounding plank (fig. 4). Any open spaces that may occur under the boards are filled by banking the earth against the boards. By this method the heat of the bed is considerably increased, especially at night, as the canvas prevents much of the rapid radiation which would otherwise take place. During drought the bed becomes excessively dry, and it is often necessary to water it two or three times a week. The bed should

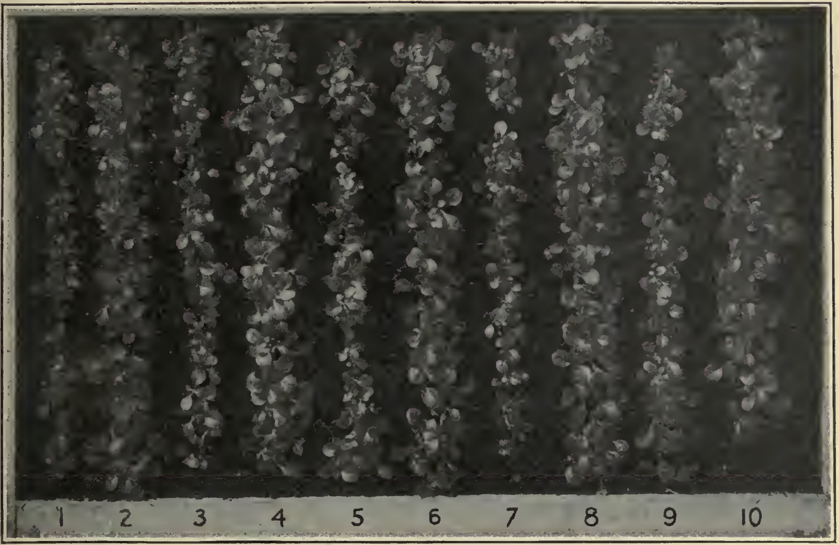

FIG. 3.—Tobacco plants in germinating box. Those from heavy seed are indicated by even numbers; those from light seed, by odd numbers.

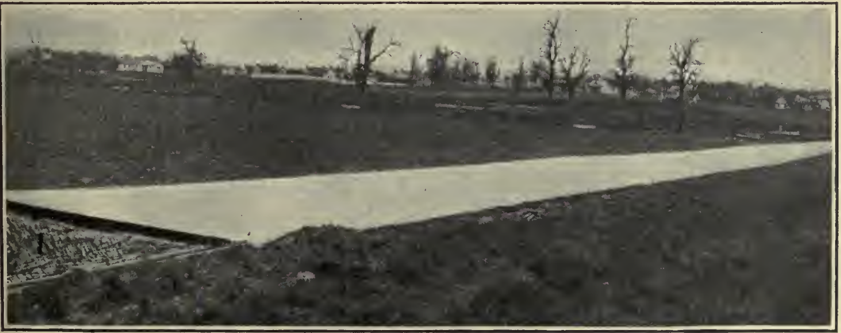

FIG. 4.—Tobacco plant bed with canvas stretched over it.

not be soaked with water, but should be thoroughly moistened. The best time for watering is late in the afternoon, to avoid baking the soil or scalding the plants.

The canvas should remain on the bed until about ten days prior to transplanting, when it should be removed, in order that the plants may become more hardy and accustomed to field conditions. If the canvas remains on too long it is commonly conceded that excessive leaf growth and too little root growth result. If the plants are growing very rapidly and give indications that they will be ready for transplanting before the desired time, the covering can be removed earlier than indicated; this will to some extent check their growth.

Insect pests sometimes cause considerable injury to the young plants. In the bed they can be controlled by the use of arsenate of lead—8 pounds in 100 gallons of water, applied with a spray pump. This insecticide does not injure the plants in any way and adheres to the foliage very well, being superior to Paris green in this respect.

SELECTION OF SOIL FOR THE CROP.

In the Burley district virgin soil is preferred for the crop. White oak, beech, walnut, maple, and hickory clearings are famous for the production of tobacco having very fine quality. The yield, however, on these newly cleared soils is not equal to that on old land in a good state of cultivation. Tracts of land that will produce good tobacco are limited even in the principal tobacco-growing districts. The average farm usually contains only a small area of land that is particularly adapted to tobacco. The soil should be fertile, friable, and abounding in organic matter to produce the best results. Very little virgin soil remains available for cultivation; consequently, tobacco growers are compelled to adopt a substitute. Bluegrass sod produces a fine quality of tobacco and gives a good yield. Clover sod gives a good yield, but the tobacco does not have the bright color that is secured from the bluegrass sod. Timothy sod is also used for tobacco, but it is not as good as those already mentioned.

No fixed and unchangeable method of rotation is practiced, though some general principles are observed with reference to preceding and succeeding crops. The usual plan of rotation is to have tobacco follow a sod of bluegrass, clover, or timothy and in turn be followed by winter grain, such as wheat, rye, or turf oats. Tobacco follows tobacco for two or, perhaps, three years when virgin soil or bluegrass sod that has not been cultivated for several years is used. The crop of the second year is usually superior to that of the first year in that it has better body and more weight. The third-year crop is often disappointing unless the soil is very fertile in the beginning. It is generally believed that six or eight years of bluegrass sod are required to restore soil to its native productive capacity, particularly with reference to the quality of the tobacco produced. Farmers who make an effort to grow a fine quality of tobacco and at the same time maintain the fertility of the soil practice the sowing of bluegrass along with clover and timothy in wheat following tobacco. In three or four years the bluegrass practically replaces the clover and timothy and will maintain a sod indefinitely. After the field has been used for three or more years for pasture it is again available for tobacco. Below is shown how this eight-year rotation is carried out. The grass or clover printed in italics is the predominant one for the particular year shown. It is assumed that a fertile virgin clearing or bluegrass sod is used to begin with.

(1) Tobacco.
(2) Tobacco.
(3) Wheat.
(4) *Clover, timothy*, bluegrass.
(5) *Clover, timothy*, bluegrass.
(6) *Timothy*, bluegrass.
(7) Timothy, *bluegrass*.
(8) Bluegrass.

Bluegrass is slow in forming a heavy sod. Advantage of this is taken by securing two crops of clover and timothy. When a four-year system is in vogue the rotation outlined below is common:

(1) Tobacco.
(2) Wheat.
(3) Clover and timothy.
(4) Clover and timothy.

To give an accurate idea of soil requirements, Mason County, Ky., may be taken as a fair representative of the Burley district. It is especially selected for illustration because it is included in the Hagerstown clay formation district, which is probably the finest tobacco-growing section of the country. The soil is a heavy brown or pale yellow loam resting on a stiff yellow clay. The Hagerstown clay was formed by the decomposition of limestone of the Upper Hudson of the Lower Silurian era. On the flat tops of some of the hills and on virgin forest areas a loose brown loam may be found. At one time the Hagerstown loam in all probability covered the area now occupied by Hagerstown clay. Continued erosion has carried the greater part of the surface soil away and in many sections the exposed limestone is outcropping. This section of the country is decidedly rolling, and frequently hills with an elevation of considerable magnitude are seen. This land produces on the average about 1,000 pounds of tobacco to the acre.

In the dark-tobacco district, virgin soil on beech, maple, hickory, white oak, red oak, and black jack clearings produces the finest quality of tobacco and is preferred to old land even though it be in a fine state of cultivation. As in the Burley district, clearing has gone on until a relatively small percentage of the land remains in forest. Farmers who have no virgin or " fresh " land to put in tobacco usually prefer clover sod to anything else. Frequently tobacco follows corn and seems to give good results.

Perhaps a definite rotation is more strictly observed in the dark district than in the Burley district. In some localities the following rotations, which have nothing in particular to commend them, are practiced:

(1) Tobacco.
(2) Wheat.
(3) Wheat.
(4) Clover.

(1) Tobacco.
(2) Wheat.
(3) Clover.
(4) Corn.

The use of some leguminous crop is particularly needed throughout this district. Hairy vetch (*Vicia villosa*) could be used to good advantage as a winter cover crop where tobacco follows tobacco. It is a leguminous crop, gathers nitrogen from the air, and grows well in some localities of the dark-tobacco district. It should be sown early in the fall at the rate of half a bushel of vetch and half a bushel of rye to the acre, or, if preferred, some other winter grain may be used. Vetch produces a trailing vine which must be supported by some other crop; if the vetch is to be plowed under in early spring before a very rank growth is attained, however, but little winter grain will be needed to support it.

A typical soil in the dark-tobacco district is that of Montgomery County, Tenn. This Clarksville silt loam of Montgomery County is a residual soil, formed by the decomposition of St. Louis limestone. The action of the air and water dissolves the calcium carbonate, leaving behind the insoluble portions of the rock, which disintegrate to form soil. The surface of this soil has a grayish, very fine silty texture. The subsoil is a yellow loam containing considerable silt and some clay. For some localities in this section a considerable quantity of chert is present, which aids in drainage. Underneath the loam subsoil is a heavy impervious red clay. This serves as a reservoir to hold in reserve moisture for growing crops in time of drought. The surface is somewhat irregular; besides being rolling there are numerous depressions caused by old sink holes. These are usually porous enough in the bottom of the basin to secure good drainage.

The soil and climatic condition of Montgomery County, Tenn., seem to be most favorable for the production of that fine, dark, export type of tobacco so highly prized in European countries.

A more complete discussion of the soil types may be found in the reports on the soil surveys of Mason County, Ky., and Montgomery County, Tenn., by the Bureau of Soils of this Department.

TIME TO BREAK THE GROUND.

Virgin soil where heavy clearings have been made and where there is no grass to contend with may be broken in the spring, sufficient time being allowed to put it in good tilth before planting.

Bluegrass sod and hillside land are usually broken in the spring. The former may be broken in the fall, and in any case should be broken early enough for rotting of the sod to take place before transplanting time. The sod should be turned under so deeply and thoroughly that in case it is not completely rotted it will not be pulled to the surface by subsequent cultivation. Clover and timothy sod should be broken in the early spring. In that way it serves as a winter cover crop for the land and is sufficiently rotted to be out of the way by planting time. Where tobacco follows corn the ground is usually broken in the spring, early enough to keep down a growth of vegetation. Where tobacco follows tobacco a cover crop of rye, winter or turf oats, or barley should be sown. This must be turned under sufficiently early for the green crop to rot. Frequently tobacco follows tobacco or tobacco follows corn and the ground is allowed to go over winter without any kind of cover crop, but this is a bad system and should not be practiced.

FERTILIZERS.

Where fertilizers are to be used, it is best for farmers to buy the ingredients and do their mixing at home. This is less expensive than buying the commercial goods, and by doing their own mixing the farmers familiarize themselves with the amount of plant food in the raw materials. By acquiring this knowledge they will be better posted as to their intelligent use. If a commercial or mixed fertilizer is to be bought it is best to buy a high-grade article, one running high in those elements in which the soil is deficient. The low-grade and low-tonnage-price fertilizers are the most expensive. Farmers pay on the average 2 cents a pound more for plant food—nitrogen, potash, and phosphoric acid—in a low-grade fertilizer than for that in a high-grade fertilizer. In some instances they pay as much as 6 cents a pound more for plant food in a low-grade fertilizer than they have to pay for it in a high-grade article, besides having to pay twice the amount for freight, sacks, and mixing to get the same quantity of plant food.

In the Burley district, where the tobacco is usually set about 18 inches in the drill, the fertilizer is scattered along in the rows, but where the tobacco is checked the fertilizer is dropped in the check. Fertilizers are sometimes applied broadcast, which is a better practice than the methods usually employed. A quicker start may be had by hill fertilizing, but a better season's growth should be produced by broadcasting, especially if the crop passes through a drought, as placing concentrated, quick-acting, soluble fertilizers too close to the roots of the young plants may injure them.

In the dark-tobacco district the usual practice is to set the tobacco in check rows and apply the fertilizer in the checks. If a drought occurs during July or August, hill-fertilized tobacco will fire worse than that broadcasted, for the reason just mentioned. The fertilizer usually gets the blame for this, while the fault lies in the method of application rather than in the fertilizer.

It is impossible to prescribe a fertilizer formula for tobacco suited to all conditions. Varying quantities of potash, nitrogen, and phosphoric acid may be required, depending on the fertility of the soil and the kind of season. By reference to Bulletin 66 of the Kentucky Agricultural Experiment Station, it will be seen that an application of potash or potash and nitrogen gives good results in the limestone region, while in western Kentucky, where the soil is deficient in phosphoric acid, actual field tests have shown that an application of phosphoric acid gives good results.

Tobacco is sometimes regarded as a potash plant, in that 1,000 pounds of crop take more potash from the soil than is taken by the same number of pounds of most crops; in fact, tobacco removes several times as much as is taken by the common crops, such as corn, wheat, cotton, and hemp. Sulphate of potash is found best adapted for tobacco. The chlorin in muriate of potash is considered injurious to both the growing plant and the manufactured article. Tobacco stalks make a valuable manure and should be hauled out and turned under in the early spring. Barnyard manure is not to be recommended where a fancy, highly colored Burley tobacco is to be produced. It can, however, be used to good advantage where a great deal of weight and body is demanded. Generally speaking, barnyard manure has a tendency to produce a coarse tobacco.

PREPARATION OF THE SOIL.

After breaking, the soil should be thoroughly harrowed and rolled, in order to reduce all clods and leave the surface smooth and mellow.

If a crust should form before transplanting, a light harrow or weeder should be used to break it. This prevents the soil from becoming dry and hard, stops excessive evaporation of moisture, and less rain will be required to afford a season suitable for transplanting.

Laying off the ground is the final operation before transplanting. A good implement for doing this is a marker constructed similar to the one shown as figure 5. A marker 7 or 8 feet long will mark off three rows in one drive. The indicator arm makes a slight mark sufficiently distinct to center with the tongue on the return trip. The arm is so constructed that it can be reversed to the other side on the return trip. For setting tobacco where it is desirable to have it 18 inches in the drill, the marker shown in the cut will lay off five rows and insure an equal number of plants to each drill. This implement does not furrow the ground; it only makes distinct crosses and the plants are set in the crosses.

In the Burley district the plants are set in rows 3½ to 4 feet apart and usually from 18 to 24 inches in the row. A greater distance between the plants, especially on rich soils, produces a coarseness of fiber that is undesirable. Plants set on poor soils should be farther apart than those on rich soils in order to secure the desired growth.

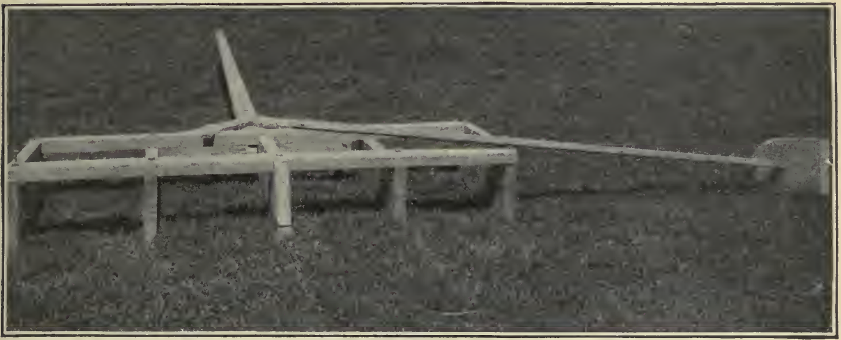

FIG. 5.—Marker used for laying off the rows for tobacco plants.

In the dark belt the common practice is to plant 3½ to 4 feet each way and cultivate in both directions.

The old method of transplanting by hand is still exclusively used in some localities. The accompanying illustration (fig. 6) shows the style of peg commonly used in setting the plants.

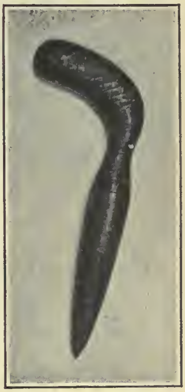

FIG. 6.—Peg used in transplanting tobacco seedlings.

A 2-horse tobacco setter is used to some extent, especially where there are large fields. With this machine about 3 acres a day can be set, three men and a team being required for its operation. Its greatest advantage is that the crop can be set regardless of season. Growers claim that a larger percentage of plants will live when set by a planter than when set by hand.

A strict rule of procedure for the cultivation of tobacco would be valueless, since soil and climatic conditions are so varied in the different sections of the country. Then, too, farmers have different kinds of tools and each one will adjust his methods to suit his supply of farm machinery. Only a general plan of procedure will therefore be suggested.

At first, use is made of a shovel cultivator or turn plow (fig. 7), run rather close and deep, the object being to stir the soil near the roots so as to admit air and warmth. Subsequent cultivation consists of shallow plowing for the purpose of preventing the growth of weeds and conserving soil moisture. The use of any tool that will carry out this purpose will give good results. The hoe is not used in tobacco cultivation so much as formerly unless the hills become infested with grass and weeds. It is used very little in the Burley district. Hilling, following the last plowing, is still considerably practiced in the dark-tobacco district. There is a common impression that it produces a heavier tobacco. Cultivation is not continued to any extent after the plants have grown so large that they would be injured from broken leaves and disturbed root systems.

TOPPING.

When fourteen to eighteen leaves appear on a plant of the Burley type or ten to fourteen on one of dark tobacco, the top is broken out so that the leaves will spread and attain the proper body and thickness.

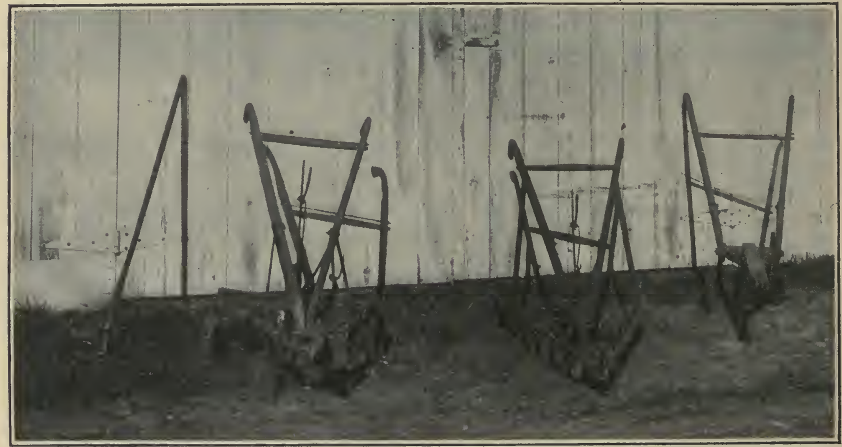

FIG. 7.—Implements used in the cultivation of tobacco.

Topping requires considerable discrimination on the part of the grower. He must be able to judge the capabilities of the individual plant and also the soil in which it grows. A slow-growing plant should not be topped as high as a rapid grower. The former will not mature as many leaves as the latter. For the same reason, plants grown on poor soil should not be topped as high as those grown on rich soil. Good judgment should be exercised in topping the plants so that they will all produce leaves of equal body, all of which will ripen at the same time. This end, of course, can be attained only approximately. High topping tends toward late maturity. An experiment on Burley tobacco at the Kentucky Agricultural Experiment Station in 1906 gave best results when the plants were topped at fourteen to sixteen leaves. The plots used had been in bluegrass sod for a number of years and were very fertile. In a second experiment plants were topped at twenty leaves, but did not produce any more pounds per acre and the tobacco was much lighter in body. Topping at twelve leaves reduced the yield very materially, especially of the bright and red leaf grades. The custom in the dark district is to prime off about four leaves next to the ground and then top from eight to ten leaves on poor soil and from ten to twelve on fertile soil.

After topping the plant, suckers are produced at the axils of the leaves. The first crop of suckers appears soon after the plant is topped, the larger ones in the top of the plant. A short time after their removal a second crop appears. The suckers are removed when they attain a length of 3 or 4 inches. They should not be allowed to remain on the plants after they get of sufficient size to be easily removed. The building material that would otherwise go into the suckers should go to the production of leaf. Very large suckers will cause the leaves to break off by pushing them partially loose from the plant, and their removal leaves ugly scars where they were formerly attached, in which rot and fungous growths sometimes occur.

METHODS OF COMBATING INSECT PESTS.[a]

There are several blowing devices for applying Paris green to destroy insect pests. A simple one consists of a bellows duster that costs about $1. The operator should be careful to dust the poison on evenly and not excessively. Burning will occur in spots on the leaves, and sometimes the whole leaf is affected. From one-half to 1 pound of Paris green is sufficient to apply to an acre of Burley tobacco, the quantity depending on the size of the plants. A less amount should be used in the dark district. Paris green is effective in destroying young worms; but large ones are not held in check very much by it, so that hand picking must be resorted to. It is necessary to apply Paris green every ten days or two weeks in dry weather, and oftener in rainy weather.

Another method of combating the hornworm, and one which might be very successful if adopted by all of the tobacco growers, is the feeding of cobalt to the moths by applying it in the flowers of the jimson weed (*Datura stramonium*). The moths frequent these flowers during the evening twilight and suck the juices found in them; after they have taken some of this poison they become sick and die.

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[a] A discussion of the insect enemies of tobacco is given in Farmers' Bulletin No. 120, entitled "The Principal Insects Affecting the Tobacco Plant," which may be obtained gratis on application to this Department. For further information in regard to these pests or methods for their control application should be made to the Bureau of Entomology, which is engaged in the special investigation of insects affecting this plant. Correspondence will be greatly facilitated if specimens of insects accompany letters of inquiry or complaint.

The cobalt solution should be made up at the rate of 1 ounce of cobalt to 1 pint of sweetened water. A few drops of this solution placed in the newly opened flowers each day will destroy the moths as fast as they appear. The jimson weed is sometimes set out around the field to entrap the moth in this way. Perhaps it would be better to set out the weed at some distance from the tobacco field, as moths in very large numbers seem to be attracted to the field by the flowers.

In the section referred to there are two periods when the worms are particularly numerous. The first visitation occurs early in July. The tobacco being small, as a rule no material damage is done. One month later a second visitation occurs that is much more serious, as the tobacco is large and the pests can conceal themselves with more ease.

SELECTION OF SEED PLANTS.

The selection of seed plants requires the grower's careful discrimination. The average farmer with a few acres should reserve ten or twelve choice plants for seed production. Out of this number he can save two or three that particularly suit his fancy. In a general way plants having leaves of good width and length are desirable. It does not follow that the biggest are necessarily the best, for coarseness is often correlated with size. The leaf should be thick and gummy and of good texture. The veins of the leaf should be far apart and at right angles to the midrib. The character of the veins should be observed and coarseness avoided. Coarse veins in the cured product injure its sale and limit the uses to which it can be put. Long internodes—distances between the leaves—are not desirable and are associated with coarse stalks, which are difficult to cure. It is commonly believed that it is better for the stalk to cure as soon after the leaf as possible. So long as the stalk is green it supplies moisture to the leaves, rendering them darker in color than they otherwise would be. In Burley tobacco, so far as color is concerned, the lighter colored green stalk is an indication of tenderness and that the tobacco will cure readily.

The seed plant should be selected by the time the "button" appears. All leaves except the number desired should be removed. A few days after the first selection the flowers will be blooming. A 12-pound manila paper bag should be placed over the head (fig. 8), so as to protect it from cross-fertilization. The procedure in bagging seed briefly alluded to here is based on the methods devised, developed, and introduced by the Bureau of Plant Industry. Details of these methods may be found in the Yearbook of the Department of Agriculture for 1904 in an article entitled "The Improvement of Tobacco by Breeding and Selection," by Mr. A. D. Shamel.

If any of the flowers have opened previous to bagging they should be removed, as in all likelihood they have been visited by insects and cross-fertilization has been accomplished. After the bags have been on about a week they should be temporarily removed and the seed head examined. All superfluous branches should be removed; also all small leaves, leaving only the "crow foot," bearing from forty to eighty pods. Weekly attention will be required as new blossoms, suckers, and leaves which require elimination are produced. The bags may be permanently removed after twenty-five days, but all flowers opening after the bags have been removed must be pruned off.

The maturity of the seed head is indicated by the pods turning brown. The heads can be taken from the field and hung up in a dry, well-ventilated place for drying. Precautions should be taken to prevent mice or birds from reaching them. Bagging is recommended because experimental evidence shows that self-fertilized seeds produce much more uniform and better plants than those promiscuously fertilized (fig. 9). Cross-fertilized seeds produce plants of widely varied characters, owing to the infusion of so many different strains. A certain plant is selected as an ideal; it is desirable to perpetuate its qualities. This can be accomplished only by excluding outside pollen. Darwin's experiments show that self-fertilized tobacco seeds have much greater prepotency than cross-fertilized seeds.

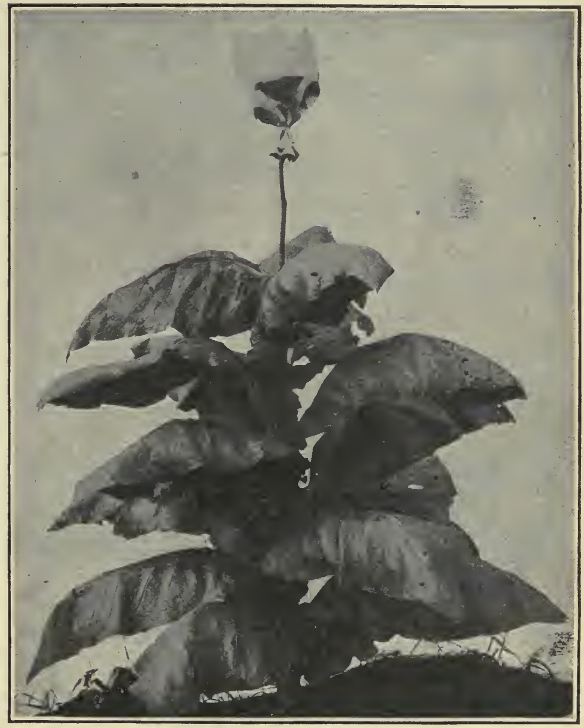

FIG. 8.—Seed head of a tobacco plant protected from cross-fertilization by a paper bag.

HARVESTING.

Ripeness of the plant is indicated by the appearance of yellow spots on the leaf and by the brittleness of the veins. Usually about thirty days after topping, the plants are ready for harvesting. The stalks are split with a knife of the kind shown in figure 10, beginning at the top and splitting to within 6 inches of the ground, and are cut from the hill just below the ground leaves.

FIG. 9.—Field of White Burley tobacco grown from seed matured under bag, only the heavy seed separated by machine being used.

Five or six plants, the number depending on their size, are placed astride a stick. Within four hours if the weather is favorable the plants will wilt enough to be taken to the barn. To prevent sunburn, it is often necessary to " scaffold " immediately after cutting. Tobacco can remain on the scaffold for two or three days, or longer if necessary. Rain will not damage it much if it has not commenced to cure. Tobacco that has yellowed well on the scaffold before taking to the barn is less likely to house-burn than if it is housed on the date of cutting, before it thoroughly wilts. In handling the crop all possible precautions are taken to prevent injury by bruising.

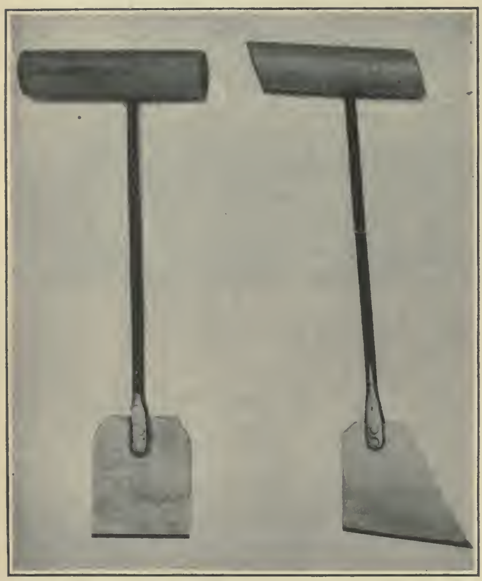

FIG. 10.—Knives used for cutting tobacco plants in harvesting.

A good frame for hauling tobacco is shown in the accompanying illustration (fig. 11).

CURING.

In the barn, sticks filled with the green plants are hung about 10 inches apart on the rails, which are usually 4 feet apart, these rails being about 4 feet apart vertically. Shaking the plants when they are being hung in the barn will prevent the leaves sticking together, which is a frequent cause of damage from house-burn, the texture and elasticity of the leaf being practically ruined when thus affected. Even if house-burn is not produced, uneven coloration is likely to result if the plants are not shaken.

The prime requisite of a barn for air-curing is that it shall be thoroughly ventilated (fig. 12). What is termed side ventilation is popular in the Burley district, i. e., the air is permitted to pass in at windows on one side of the barn directly through and out of windows on the opposite side. The old method was designed to admit air at the side and provide an exit at the top. The movement of the air is effective in driving a current through the barn and is more likely to give good results than is dependence upon a rise of temperature to carry the draft out at the top. For the protection of tobacco hanging in the comb of the barn some ventilation at the top can be provided, since tobacco in this portion of the barn is not much affected by the side draft. To accomplish the ventilation desired, windows should be arranged horizontally the full length of the barn, parallel with each tier, so that a current of air may pass between the butts and the tips of the tobacco on each set of rails. The windows should be about a foot wide and the length of a bin, usually 12 feet. Ventilators about 2 feet square may be located every 25 feet in the comb of the barn.

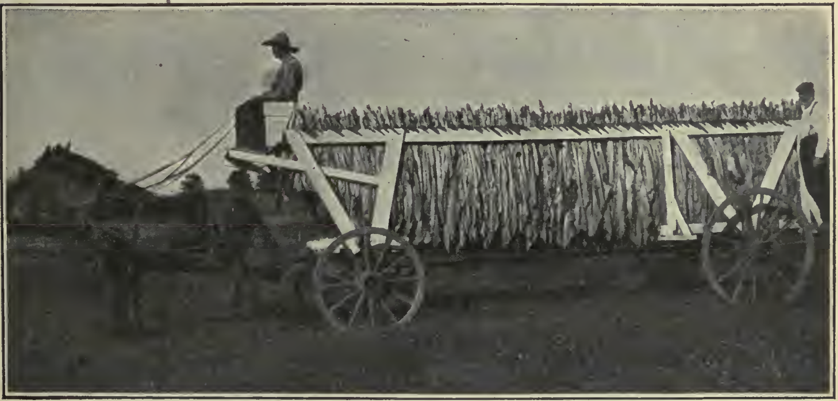

FIG. 11.—A good frame for hauling tobacco to the barn.

The general principle upon which air-curing proceeds is that the tobacco dries during the day and comes "in case," or takes up moisture, during the night. The barn should be opened in the morning, kept open all day under normal conditions, and closed at night during damp weather. During dry weather while the tobacco is curing it is desirable to keep the barn open both day and night unless strong winds prevail which would break or bruise the tobacco.

The most trying time is during fogs and warm drizzling rains when there is very little air stirring. Under such circumstances the air on the outside is saturated with moisture and the barn should be kept closed until the air reaches the saturation point within, which will be indicated by the sweating of the tobacco. Then it is better to open the barn and get the benefit of whatever draft there may be outside. Open fires of coke or charcoal are placed about on the floor of the barn whenever the draft is insufficient or the humidity so great that sweating continues. This creates a draft and increases the water-holding capacity of the inclosed air. Sweating may continue for forty-eight hours without serious injury, but if continued longer than this house-burn may occur and render fires imperative. The first two weeks is the critical period of curing; if no damage has been done at the end of that time the tobacco is comparatively safe. But even then, unless there is a very humid atmosphere, the barn should not be closed so tight that the air can not circulate through it. Two

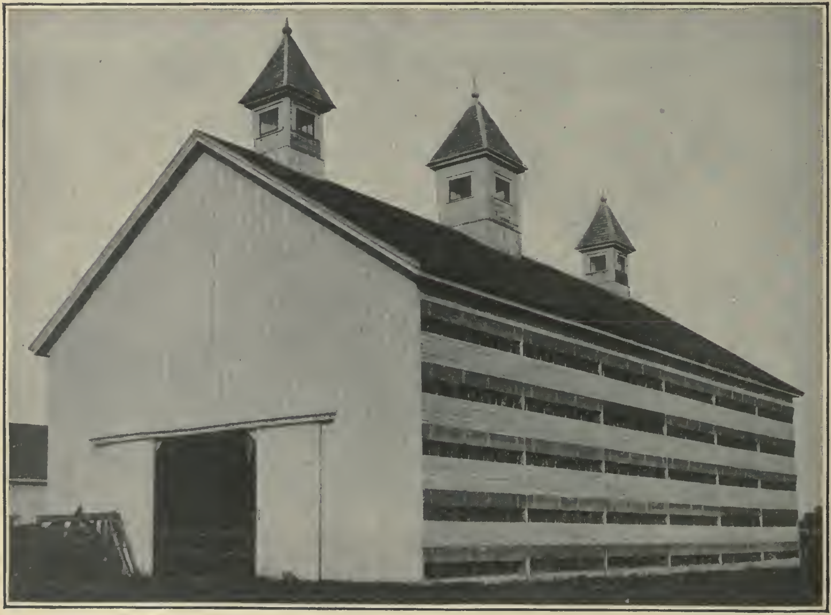

FIG. 12.—A well-ventilated barn for air-curing tobacco.

months are ordinarily required before a crop is sufficiently cured to be bulked and stripped out.

In the dark-tobacco belt fire-curing is practiced. The sticks are crowded to about 6 inches apart on the tiers, the space being governed to some extent by the size of the tobacco, and very little regard is paid to ventilation. About five days after the crop has been housed (fig. 13) the yellowing process is completed and firing begins. If indications of house-burn should occur earlier it will be necessary to begin firing sooner than indicated. The first two or three days slow fires are applied so as to continue the yellowing process. Hotter fires follow until the curing process is practically complete.

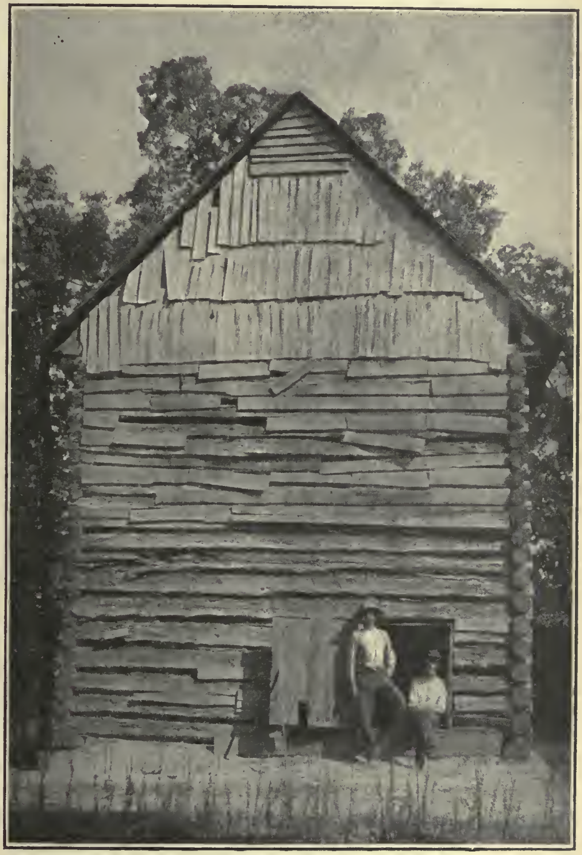

FIG. 13.—A log barn still used for fire-curing tobacco.

The practice is quite common after about one week's firing to allow the tobacco to "run," i. e., to come in case, which will be facilitated by the amount of moisture still remaining in the stem and stalk. As soon as the tobacco is in case, slow fires are added again, but continued for only a short time. "Running" is not practiced as much as formerly by many of the best growers. A common mistake is made by attempting to cure the crop too quickly, and green and off colors are set. Careful planters often fire for about ten days. Wood—hickory and oak are preferable—is used in firing. The odor and flavor imparted to tobacco by the smoke of wood are necessary where an effort is made to produce a dark export type. Coke and charcoal impart no flavors and for this reason are invaluable in emergency cases when Burley tobaccos are being cured.

STRIPPING AND GRADING.

Planters take advantage of rainy days during the winter to strip their crop. The moist air brings the crop in case so that it may be bulked in large piles; then it will not go out of case when fair days return. Care needs to be exercised not to bulk tobacco when it is not in case sufficiently, because it will be difficult to handle and breaking will occur. If tobacco is going out of case when bulked, it will continue to go out and become dry. Very high case must be guarded against, as tobacco will become very dark in the bulk, especially if much rainy weather follows. Bruising is likely to occur when tobacco in high case is handled. Tobacco bulked down in "winter order" during the winter months will funk during the months of April and May if not taken up and hung back in the barn to dry out. After June it can be taken down and bulked or prized in "summer order"; then it will keep for years.

Burley tobacco is assorted into five different grades, according to the color and body of the leaf. Beginning at the base of the stalk, the grades come in regular order as follows: Flyings, trash, lugs, bright leaf, and red leaf. The flyings are the light chaffy leaves at the base of the stalk; usually one or two leaves from each plant go in this grade. The trash is a little better grade than the flyings, and is usually of a bright color. The next grade is the lugs, which are of a bright color, and like the trash command the best price on the market. The bright leaf is the finest grade in appearance, but frequently does not sell for so much per pound as the trash and the lugs. From these bright grades already mentioned a special grade called "cigarette" is sometimes made. This includes only the best and brightest leaves, practically free from dark colors. Red leaf is the top leaves of the plant and is not so valuable as the bright leaf. The general principle to be observed is to secure uniformity of qualities within the same grade.

Dark tobacco is graded according to the same principle as Burley tobacco, but only three grades are made. This tobacco is usually topped at ten leaves; hence there is less opportunity for producing as many grades.

MARKETING.

Tobacco is sold either prized or loose. Selling loose is the less expensive way, and if markets and handling houses are near, farmers can readily take advantage of it. When the market is at a distance or it is desirable to reach a better market, the product can be packed in casks or hogsheads containing about 1,500 pounds. Only one grade should be put in a hogshead; if it is necessary to put in more, they should be separated by a layer of paper. The more attention that is given to careful packing, so as to avoid a mixture of grades within the same bulk or cask, the more satisfactory sale returns will be received.

Tobacco packed during the winter, in winter order, will not keep through what is termed the May "sweat." To prevent it from funking and rotting during this sweating period one must take it up and dry it out, after which it may be repacked in June order; then it will keep indefinitely.

Burley tobacco is bought largely to supply the home market. It is used in the manufacture of smoking tobacco, cigars, and plug for chewing. Great Britain imports a considerable quantity of Burley tobacco for the manufacture of plug. The bright red leaf formerly furnished from the Green River district is now being supplied in part from the Burley district. Germany takes a considerable quantity of the inferior grades. Other European countries use limited amounts.

Fire-cured tobacco is superior to Burley in keeping quality. Dark tobacco packed in good condition during the winter months can be relied upon to pass through the May sweat. It is a good practice, however, to prize this tobacco in June order.

Dark tobacco is used mainly for export purposes and is particularly sought by English, German, Italian, French, Spanish, and African dealers. Sharp lines of distinction are hard to draw between many of the export types. Intermediate grades are generally sought by more than one market. Italian buyers would not hesitate to take certain Austrian grades if they could get them at Italian prices. If there is a shortage of Bremen tobacco, the manufacturers, through their representatives, at once proceed to buy the nearest approximation to the desired type.

In a general way the following classification applies to the export tobaccos: The English market takes grades varying in color from a bright red to a dark brown. The German market in former years preferred an article varying from a chocolate to a full brown color, rich and oily, of good body and strong, elastic texture. In later years there has been a growing demand for brighter colors. A strong, elastic texture is required for the English and German spinners, as the tobacco is twisted into a long coil after the fashion of a rope.

The Italian market takes grades ranging from a cherry red to a deep brown color, the better grades having a smooth, silky finish. The scale of qualities is represented alphabetically. *A* refers to the best grade and consists of a leaf from 25 to 26 inches long and of fine texture and fiber. This type is used largely for cigar wrappers. Grades *B* and *C* measure from 22 to 25 inches and from 18 to 22 inches, respectively, and approach the quality of *A* as nearly as possible. Intermediate grades are designated as *AB* and *BC*. These tobaccos are utilized mainly for cigars.

The types exported to Austria are regarded as of a higher class than the Italian and consist of grades of lighter shades of color. The Austrian type lacks the body of the Italian, but possesses superior finish and silkiness.

The wrapper demanded by the Swiss, which measures from 25 to 30 inches, is usually regarded as the highest development of the Austrian type.

The French and Spanish trades require the extreme of the light-bodied tobaccos. The better French classes command a very good price, while the Spanish is a cheap, nondescript tobacco.

The type of tobacco required in Africa consists of a very long, narrow leaf with plenty of body but coarse fiber and grain. Finish and quality are not considered. Tobacco for this trade is usually called "balers."

FARMERS' BULLETINS.

The following is a list, by number, of the Farmers' Bulletins available for distribution. The bulletins entitled "Experiment Station Work" give in brief the results of experiments performed by the State experiment stations. Titles of other bulletins are self-explanatory. Bulletins in this list will be sent free to any address in the United States on application to your **Senator, Representative, or Delegate in Congress,** or to the Secretary of Agriculture, Washington, D. C. Numbers omitted have been discontinued, being superseded by later bulletins.

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FARMERS' BULLETIN No. 344.

THE BOLL WEEVIL PROBLEM,

WITH SPECIAL REFERENCE TO MEANS OF REDUCING DAMAGE.

BY

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1909.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., November 20, 1908.

Sir: I have the honor to transmit herewith the manuscript of a paper, by Mr. W. D. Hunter, agent in charge of southern field crop insect and tick investigations in this Bureau, dealing with the boll weevil, especially with reference to means of reducing its damage. So many publications upon different phases of the boll-weevil problem have been issued by this Department during the years since the weevil has invaded the United States that it has seemed advisable to present a summary in a single paper of the practical results recorded therein and including the results, as yet unpublished, of the most recent investigations. This purpose has been carried out in the present paper, the publication of which as a Farmers' Bulletin is hereby recommended, superseding No. 216.

Respectfully,
L. O. Howard,
Entomologist and Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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THE BOLL WEEVIL PROBLEM, WITH SPECIAL REFERENCE TO MEANS OF REDUCING DAMAGE.

INTRODUCTORY.

This bulletin, dealing with work done under the direction of Dr. L. O. Howard, Chief of the Bureau of Entomology, is intended to cover in a general way the whole field of the control of the boll weevil. As this control is inseparably connected with the life history and habits of the insect and, in fact, must be based thereon, attention is given to the principal features of the insect's economy. In addition, information is given relating to the amount of damage done, the extent of the infested territory, and such other matters as are of special interest at this time.

Like many of the most important injurious insects in this country, the cotton boll weevil is not a native of the United States. Its original home was undoubtedly in the plateau region of Mexico or Central America, and it may originally have fed upon some plant other than cotton. This is not necessarily the case, however, since there is evidence that the same region is the original home of the cotton plant itself. Previous to 1892 the insect had spread through Mexico, but little is known regarding the extent or rapidity of this dispersion. The records indicate, however, that it had probably caused the abandonment of cotton in certain regions. About 1892 the boll weevil crossed the Rio Grande near Brownsville, Tex. It may have flown across, or it is possible that it was carried over in seed cotton to be ginned at Brownsville. By 1894 it had spread to a half dozen counties in southern Texas and was brought to the attention of the Bureau of Entomology. A preliminary examination, made under the direction of Dr. L. O. Howard by Mr. C. H. T. Townsend, showed the enormous capacity for damage of the pest. Subsequent events have verified in every way the predictions that were made at that time, when the insect had not attracted any considerable amount of attention in the South. Since 1894 the boll weevil has extended its range annually from 40 to 70 miles, although in two instances the winter conditions have been such as to cause a decrease in the infested area. During the first ten years after its advent into this country the annual rate of spread was 5,640 square miles. Since

1901 the annual increase in the infested territory has averaged 26,880 square miles, but in one exceptional season, namely, 1904, 51,500 square miles became infested. Of course, the figures given do not refer to the area in cotton. In many parts of the infested territory the area devoted to cotton is much less than 10 per cent of the total area.

At the present time the weevil is found more or less extensively in five States—Texas, Louisiana, Mississippi, Arkansas, and Oklahoma. In Mississippi 18 counties are infested, in Arkansas 28, and in Oklahoma about one-fifth of the State. The total area infested comprises about 225,000 square miles and this covers about 36 per cent of the cotton acreage of the United States. (See fig. 1.)

DAMAGE.

The damage done by the boll weevil varies greatly from year to year and also in different parts of the infested area. As the rainfall increases the damage becomes greater. In prairie regions, where the insect obtains but little protection through the winter, it never becomes as numerous as in other quarters where favorable conditions for hibernation are found. These facts, together with variations due to winter conditions, make it rather difficult to estimate the exact damage that has been done. Some years ago the writer stated, from the statistics then available, that the weevil caused a reduction of at least 50 per cent of the cotton crop in regions invaded by it, but that after the first few years the farmers generally resorted to proper means to greatly reduce this loss. In many individual cases the means of control perfected by the Bureau of Entomology have been applied so successfully that the crop has been fully as large as before the coming of the weevil. This was not accomplished, however, without somewhat increasing the cost of production. The estimate of an initial falling off in production of 50 per cent was verified by Prof. E. D. Sanderson, formerly State entomologist of Texas, who arrived at his figures in an entirely different way.

The average yield per acre in Texas from 1893 to 1901 (when the weevil had not done damage sufficient to affect the general production) was 0.40 bale. The average since that time, 1902 to 1907, was 0.35 bale. By comparing these periods we have a reasonably accurate basis for estimating the damage the insect has done. The difference is 0.05 bale, or 25 pounds of lint per acre each year. At current prices this means an annual loss of at least $2.25 per acre which has been sustained by the cotton planters of Texas. Assuming that the Texas acreage has averaged 10,000,000, the total loss for the State has annually been $22,500,000.

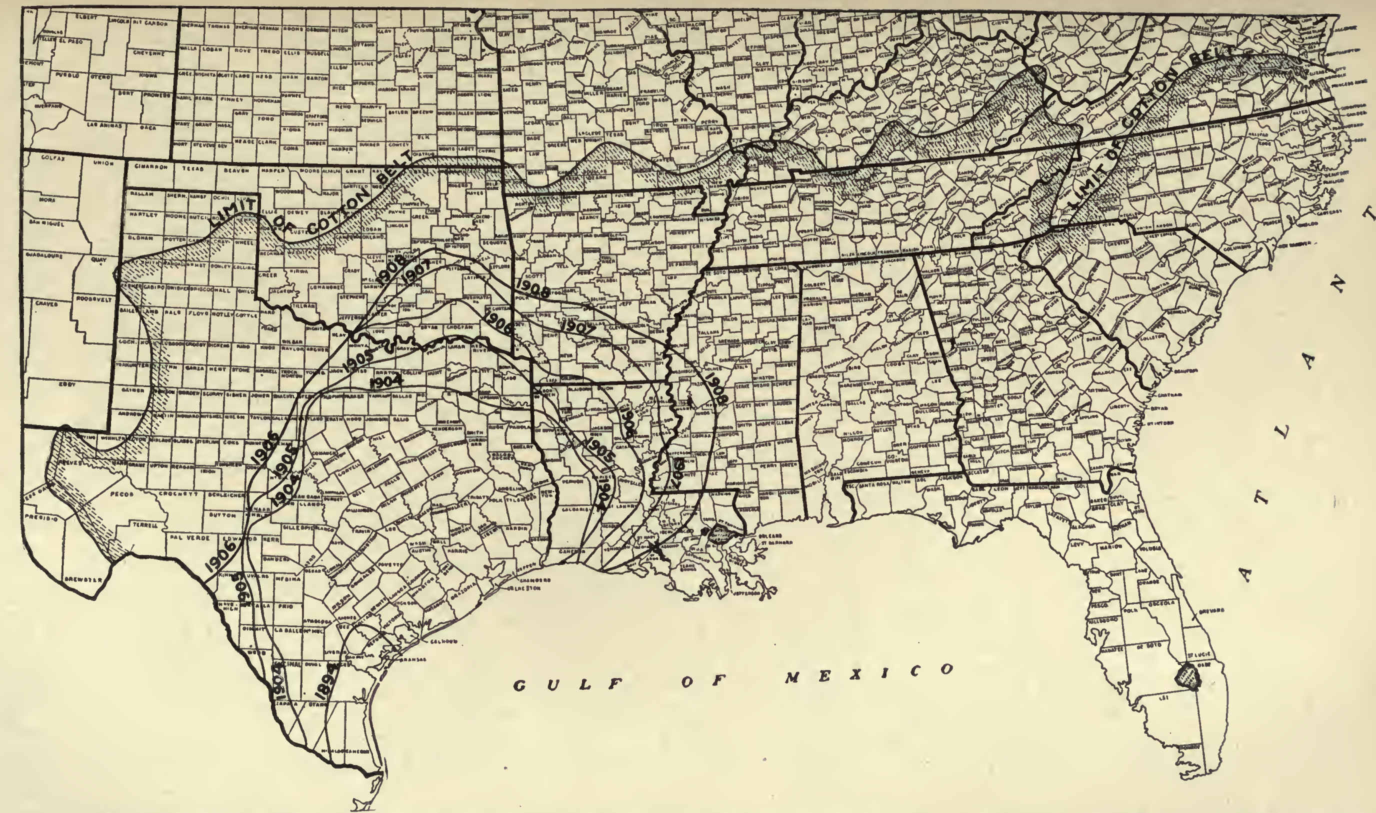

FIG. 1.—Map showing area infested by the boll weevil in 1908 and during various preceding years. (Original.) The line for 1908 includes all territory in which any infestation has been found. Toward the outer part of the infested area very few weevils are to be found. This applies to a belt from 5 to 25 miles wide bordering the line for 1908 on the inside.

Another tangible indication of the manner in which the weevil has affected cotton production is revealed by a comparison of statistics from Louisiana and Texas. From 1899 to 1904 the acreage in Texas and Louisiana increased at about the same proportion, but the crop in Texas decreased at the same time that the crop of Louisiana was increasing. There is an exception to this statement in the years 1900 and 1904, in which the production in Texas did not decrease, but these years were exceptionally unfavorable for the weevil and at the same time very favorable for the general growth of the cotton. In 1907 the yield per acre in Texas (0.24 bale) was the smallest in her history. This followed a winter so mild that more than the usual number of weevils overwintered.

Undoubtedly for several years the boll weevil has caused a loss of about 400,000 bales of cotton annually. Although farmers in older regions, in many cases, are increasing their production, there is loss in the newly infested regions which offsets that gain. A conservative estimate shows that since the weevil has invaded this country it has caused a loss of 2,550,000 bales of cotton, at a value of about $125,000,000.

PROSPECTS.

Reference has been made to the greater damage inflicted in moist regions and where the shelter for hibernation is best. The records of the Weather Bureau show that the annual precipitation increases very rapidly from the West to the East in the cotton belt. This is especially the case during the early growing season of cotton, namely, April, May, and June. The precipitation in the greater part of the cotton-producing area in Texas is normally about 40 inches. In Louisiana, Mississippi, and the eastern States of the cotton belt it is more than 50 inches, and sometimes exceeds 60 inches. The records that have been kept in Texas show that the damage has always been greatest in wet seasons and that the insect has affected land values most where the general conditions approach those of the eastern part of the cotton belt. Without the assistance that is furnished by climatic conditions, especially dry weather during the spring, the farmers of Texas would not have been by any means as successful in producing cotton during the last few years as they have. The system of control outlined in this bulletin increases greatly in effectiveness when assisted by weather conditions. Fortunately in Texas this assistance is given under normal conditions. When this assistance is above the normal, as in 1904 and 1906, the crops will be exceedingly large.

On the other hand, it is clear that the problem of the control of the boll weevil will be more difficult as the pest continues its invasion of the cotton belt. It can not be considered, therefore, that the problem is as yet completely solved. Better means of control must be devised for the region that is becoming invaded, and, if possible, means must be devised that will reduce the enormous loss that is suffered, especially during unfavorable seasons, in Texas. The principal work of the Bureau of Entomology at this time is in attempting to devise means for this requisite additional control.

For the present there is no occasion to lose hope. Though the eastern planter must expect a more serious problem than that which confronted the farmers of Texas, the means of control outlined in this bulletin, especially the destruction of the hordes of weevils about to enter winter quarters, will enable him to continue production, though probably at a reduced profit. The sooner he adapts his plantation management to the necessary changes the less the loss will be.

WORK UPON WHICH THIS BULLETIN IS BASED.

As has been stated, the danger from the boll weevil was appreciated from the beginning by Dr. L. O. Howard, Chief of the Bureau of Entomology. For about ten years, more or less continuous work on the vulnerable points in its life history and the possibility of control in various ways has been done. At first this was not extensive, although it showed the essential steps necessary in the control of the pest. Later Congress made available large appropriations for the exhaustive investigation of the insect and of means of reducing its damage. Work was begun under the first large appropriation by the establishment of a laboratory at Victoria, Tex., and the beginning of extensive field experiments. It has been the practice from the beginning to carry on field experimental work in direct connection with the laboratory investigations. All means of control suggested by the laboratory work have immediately been tested on large field areas. Later the headquarters of the investigation were moved from Victoria, Tex., to Dallas, Tex., on account of the continued spread of the insect and the necessity for a central location. The Bureau of Entomology has conducted experiments during several seasons on a total of more than 10,000 acres of cotton. This experimental work has been located on well-known plantations throughout the infested territory. The special requirements in different regions have been given particular attention. Almost invariably successful crops have been produced, although special damage, due to local conditions in different regions, has sometimes interfered with the success of the experiments. The present bulletin contains a very condensed report of the results of all this work. The recommendations have all been placed in practical operation under the actual conditions prevailing on different cotton plantations.

Aside from the work directly relating to the boll weevil, which has been conducted by the Bureau of Entomology, the Bureau of Plant Industry of this Department has carried on investigations in its province. These have dealt with the breeding of cottons to obtain earliness and productiveness and with the extensive demonstration of the efficiency of the system of control devised by the Bureau of Entomology as the result of careful studies in the field and laboratory.

In addition to the work done by the Department of Agriculture the States concerned have done their part. Several entomologists have been employed by the State of Texas, namely, F. W. Mally, E. D. Sanderson, A. F. Conradi, and C. E. Sanborn. They have dealt with the boll weevil in connection with the numerous other entomological problems of the State and have contributed valuable results that have been made use of in this bulletin. The State of Louisiana has also done very notable work. Prof. H. A. Morgan and, later, Mr. Wilmon Newell, have added considerably to our knowledge of the weevil and the means of controlling it. In many ways their results are incorporated in this bulletin.

DESCRIPTION AND LIFE HISTORY.

The adult boll weevil is about one-fourth of an inch in length, varying from one-eighth to one-third of an inch, with a breadth about one-third of the length. This measurement includes the snout, which is about one-half the length of the body. Variation in size is due to the amount of food the insect has obtained in the larval stage. Individuals from bolls are therefore nearly always larger than those from squares. The color (grayish or brownish) depends upon the time that may have elapsed after transformation into the adult stage. The recently emerged individuals are light yellowish in color, but this passes to a gray or nearly black shade in a few weeks' time. The general appearance of the insect will be evident from the accompanying illustrations (fig. 2).

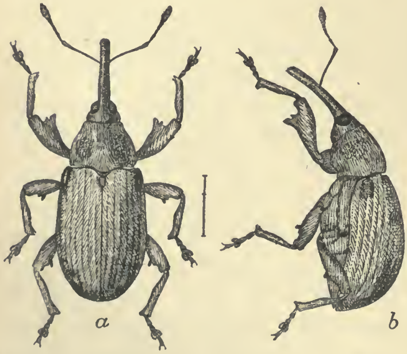

FIG. 2.—Cotton boll weevil: *a*, Beetle, from above; *b*, same, from side. About five times natural size. (Author's illustration.)

Many insects resemble the boll weevil more or less closely. In fact, there are hundreds of species of weevils in this country that may easily be mistaken for the enemy of cotton. Many mistaken reports about the occurrence of weevils far outside of the infested area have been due to mistakes that have arisen on account of this similarity. The only safe way to determine whether any insect is the boll weevil is to send it to an entomologist for examination. In the field the most conspicuous indication of the presence of the boll weevil is the flaring (fig. 4) and falling of great numbers of squares. However, unfavorable climatic conditions and careless cultivation frequently cause great shedding. If excessive shedding be noticed and the squares upon being cut open show a white, curved grub (fig. 5) that has fed upon the contents, there is little doubt that the boll weevil is the insect causing the damage.

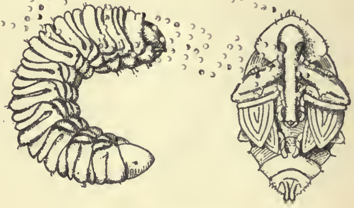

FIG. 3.—Cotton boll weevil: Larva at left, pupa at right. About five times natural size. (Author's illustration.)

The boll weevil passes the winter in the adult stage. In the spring and throughout the fruiting season of cotton the eggs are deposited by the female weevils in cavities formed by eating into the fruit of the plant (see fig. 4). An egg

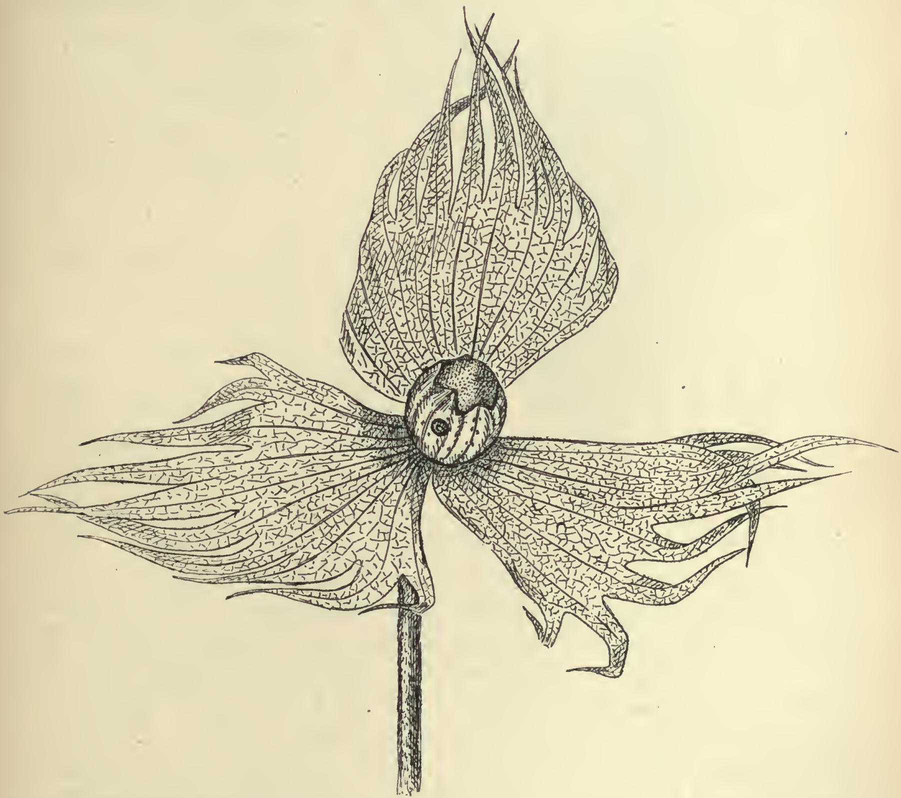

FIG. 4.—Cotton square showing egg puncture of boll weevil and "flaring" of bracts. Natural size. (Author's illustration.)

hatches under normal conditions in about 3 days and the grub immediately begins to feed. In from 7 to 12 days the larva or grub (fig. 3, at left) passes into its pupal stage (fig. 3, at right), corresponding to the cocoon of butterflies and moths. This stage lasts from 3 to 5 days. Then the adult issues and in about 5 days begins the production of another generation. Climatic conditions cause considerable variation in the duration of the stages, but on an average it requires from 2 to 3 weeks for the weevil to develop from the egg to the adult. Males and females are produced in about equal numbers. The males feed upon the squares and bolls without moving until the food begins to deteriorate. The females refrain from depositing in squares visited by other females. This applies throughout most of the season, but late in the fall, when all the fruit has become infested, several eggs may be placed in a single square or boll. As many as 15 larvæ have been found in a boll. The squares are greatly preferred as food and as places for depositing eggs. As long as a large supply of squares is present the bolls are not damaged to any serious extent. The bolls, therefore, have a fair chance to develop as long as squares are being formed. Whenever frost or other unfavorable weather causes the plants to cease putting on squares the weevils attack the bolls. A conservative estimate of the possible progeny of a single pair of weevils during a season beginning on June 20 and extending to November 4 is 12,755,100.

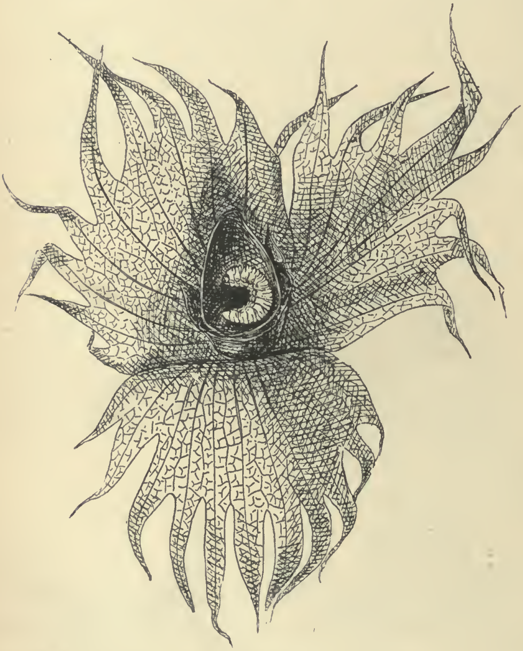

FIG. 5.—Cotton square showing boll weevil in position. Natural size. (Author's illustration.)

The cotton boll weevil, as far as known at present, has no food plant other than cotton. This has been determined by planting various plants related to cotton in the vicinity of infested cotton and in cages in which weevils were placed. It has therefore been demonstrated beyond any doubt whatever that the insect is restricted to the cotton plant for food. When confined in bottles, the weevil will partake of various substances, such as apples or bananas; but this is only under the stress of starvation. Under natural conditions they would pay no attention to these substances.

The boll weevil is strictly diurnal in its habits. Repeated observations made in the field at night have shown that it is not active after sundown. Unlike some related insects, it is not attracted to lights. The fact that somewhat similar species do come to lights in great numbers at times has frequently caused unfortunate confusion.

An interesting habit of the boll weevil is to feign death; that is, to " play possum " or " sull," as it is popularly called. When disturbed, the insects generally contract their limbs and drop to the ground. This habit is not equally strong in all individuals. It has been taken into consideration in plans of control, as will be described beyond.

The age to which weevils live varies under different conditions. During the winter the longevity is much greater than in the summer. During the summer season the majority of weevils do not live longer than 60 days. During the cooler part of the year many of them live as long as 6 months. The longest-lived weevil on record lived from December 10 to the following October, a period of about eleven months. Undoubtedly such prolonged life is exceptional.

HIBERNATION.

As has been pointed out, the boll weevil passes the winter in the adult stage. In the fall when frosts occur, immature stages may be found in the squares or bolls. Provided the food supply is sufficient, many of these immature stages continue their development at a very slow rate and adults finally emerge. Thus there may be a somewhat continuous production of adults during the winter. Ordinarily, however, this is not conspicuously the case, since the frosts that destroy the cotton generally kill practically all of the immature stages of the weevil.

With the advent of cool weather in the fall the adult boll weevils in cotton fields begin to seek protection against the winter. They fly from the fields in every direction, although their movements are governed partially by the prevailing winds. They may fly into hedges, woods, cornfields, haystacks, farm buildings, or other places. Specimens have been found in such situations, and also in considerable numbers in Spanish moss growing from trees some distance above the ground. A number of weevils also obtain hibernating quarters without leaving the cotton fields. These may crawl into cracks in the ground under grass, weeds, and other trash, and into the burrs from which the cotton has been picked. In some cases several thousand weevils per acre have been found hibernating in such situations. Here, however, the mortality is greater than where the protection is better. The majority of weevils that hibernate successfully do not pass the winter in the cotton fields. This has been shown by many experimental observations, and is demonstrated every year in the infested territory by the appearance of the first damage in the immediate vicinity of weeds and other places where conditions for protection are favorable.

During the winter the weevils take no food and remain practically dormant. On especially warm days they may move about to a certain extent. During the very mild winter of 1906–7 hibernating weevils were found moving about more or less throughout the period from November to March.

The number of weevils hibernating successfully has been determined very accurately for different conditions. Out of 25,000 weevils 2.82 per cent survived the winter of 1905–6. These weevils were placed in a variety of conditions that must have approached those which weevils must naturally encounter. The winter referred to was practically a normal one as far as temperature and precipitation were concerned. In extensive work during the winter of 1906–7, out of 75,000 weevils 11.5 per cent survived. As in the preceding case, these weevils were placed under diverse conditions in different cages. These conditions ranged from the most favorable to the least favorable, i. e., from an abundance of protection to practically none. The survival obtained is undoubtedly very close to that occurring under diverse natural conditions of that winter. It must be emphasized that the winter of 1906–7 was abnormally warm. It is undoubtedly true that the rate of survival was much higher than usual. It is supposed that the results of the previous year must approach the average. In other words, less than 3 per cent of the weevils entering hibernation can be expected to survive the winter under average conditions. The tremendous importance of still further reducing this percentage must be evident.

Emergence from hibernation depends primarily upon temperatures in the spring, although there are other minor factors concerned. Generally, from the first to the middle of March the temperature has become high enough to cause weevils to begin to emerge. Naturally, the individuals under the heaviest protection are affected latest by the temperature. The consequence is, that emergence from hibernating is a prolonged operation. During one season (1906) it extended from the middle of March to the 28th of June; during another (1907) from the middle of February to about the first of July. During each of these periods there was a comparatively short time—about ten days—of rapid emergence, preceded by an initiatory movement and followed by a period during which the number emerging day by day decreased with rapidity.

HOW NATURE ASSISTS IN DESTROYING THE BOLL WEEVIL.

In the preceding paragraph attention was called to the possible production of 12,755,100 offspring in a single season by one pair of weevils. As a matter of fact, nature has provided a number of agencies that serve to prevent such excessive multiplication. The most conspicuous of these agencies are heat and insects that prey upon the weevil.

Effects of heat.—When infested squares fall to the ground they may become so heated that the larvæ are killed in a very few minutes. The insect in this stage can not leave the square, as it has no means of locomotion whatever. Where the infested squares are subjected to the unobstructed rays of the sun the mortality is very high. This explains the well-known fact that dry seasons are unfavorable to the weevil, and indicates great difficulty in controlling the insects in regions where the precipitation is heavy. The more rankly the plants grow and the more the ground is shaded, the less effect in weevil control can be expected from heat. Nevertheless, in many cases in Texas the enormous total of 40 per cent of all the immature weevils in cotton fields inspected have been found to be destroyed through this agency. It was also found, from examinations in many quarters, that the extent of destruction held a direct relation to the amount of shade. When there was no shade practically all of the larvæ and pupæ were killed outright. Some of the important means of control, to be described later, are based upon this consideration.

Insect parasites.—The second of the important agencies provided by nature for the control of the weevil is a large number of predaceous insect enemies. These consist of a variety of forms which prey upon the boll weevil. Forty-five species of these enemies are known. Of these, 23 are parasites, which by means of their ovipositors place eggs on the immature stages of the weevil within the square or boll. The young of the parasite develops by feeding upon the immature boll weevil, which it ultimately kills. A parasite instead of a boll weevil emerges from the injured fruit. Special studies on these parasites have led to many suggestions for practical control. Moreover, the parasites seem naturally to be increasing in numbers and effectiveness against the boll weevil. In one instance in 1907 the mortality due to parasites in a field near Robson, La., was 77 per cent. About the same time 61 per cent of the weevils in a certain field near Victoria, Tex., were killed by parasites. These enemies of the weevil have existed in the country for an indefinite time. Their natural habit has been to prey upon weevils more or less related to the boll weevil that have occurred in this country for many years. They never feed on vegetation. It is undoubtedly true that they are now turning their attention from the original hosts, which are generally not very numerous, to the boll weevil, which offers abundant and favorable opportunities for reproduction. They thus ally themselves with the farmer for the protection of the cotton crop. In the following pages numerous suggestions will be made regarding the means that the farmers may take to increase the effectiveness of the work of these parasites in reducing the numbers of the boll weevil.

Other insect enemies.—In addition to the true parasites described above, the boll weevil suffers from a number of insects which are not parasites in a strict sense but prey upon it as food. The principal ones of these predatory enemies are ants. Of these, 12 species are known to attack the weevil. They are the minute brown ants and yellowish ants that occur frequently in cotton fields and are observed running over the plants or on the ground. Their work is not against the adult weevils, but against the immature stages in the squares. Some species devote their attention principally to the squares that have fallen to the ground, while others habitually seek the insects within the squares that remain hanging on the plants. The larva of the weevil, incased in a thin covering, offers a source of food that the ants are not inclined to overlook. They gnaw through the thin shell inclosing the weevil larva and the latter is soon destroyed. In some cases more than half of the immature stages in fields have been found to be destroyed by ants alone. To find 25 per cent so destroyed is not a rare occurrence. In this bulletin methods will be pointed out for making use of these friends of the farmer and increasing the important effect they naturally have in reducing the numbers of weevils.

Other factors in natural control.—In addition to the principal factors in natural control which have been mentioned there are several of minor importance. Among these may be mentioned proliferation, which sometimes crushes the immature weevils, and determinate growth, which may prevent the development of the fall broods of the weevil. Attention is also called to the agency of birds in the destruction of the boll weevil, which has been given full attention in the publications of the Biological Survey of this Department.

DISSEMINATION.

The boll weevil moves from place to place by flight. Although it is a weak flyer compared with many insects, it has been known to cover a distance of more than 40 miles in a very short time. Its flight can not be prolonged, but successive short flights, especially in connection with favorable winds, often carry the insect to considerable distances. This is the case, however, only during the so-called dispersion period, which extends from about the middle of August to the end of the season. During the rest of the year the weevil is little inclined to fly. There is always a movement from fields in all directions in search of hibernating quarters in the fall and a corresponding movement from such quarters to the cotton fields in the spring. Nevertheless, when the insects reach cotton fields in the spring there is little further movement until the general dispersion begins. Ordinarily between the middle of August and the first of September the weevil seems to be seized with an instinct to migrate. It was thought at one time that this movement was forced by excessive reproduction and took place only when all squares and bolls, or the majority of them, became infested. Investigations have shown, however, that the dispersion takes place frequently when the fields are only slightly infested. In other words, the insect has a well-developed instinct for extending its range into new territory. It is this instinct that has caused the extension of the infested area in the United States year by year. The weevil does not fly in any particular direction except as governed by the wind. If there is no wind or only a light one, a weevil is as likely to fly in one direction as in another. The individuals carrying the infestation into new regions have been those that happen to radiate in the direction of previously uninfested territory.

The fact that the weevil moves about but little except at one season is of great benefit to the farmer. As the movement referred to does not begin until after the time when a crop is normally made, it amounts to but little after a region has become infested. On the other hand, the limited movement at other times of the year makes it possible for any individual farmer to obtain the best results from his own efforts in fighting the pest. The danger of his efforts being thwarted by the arrival of weevils from fields where no precautions have been taken is not as important as is sometimes considered. In fact, it is not important enough to warrant any farmer in deferring action on account of the indifference of his neighbors.

The above statements give only an outline of the life history and habits of the boll weevil. More complete information can be obtained from Bulletin 51 of the Bureau of Entomology, which may be obtained for 15 cents upon application to the Superintendent of Documents, Government Printing Office, Washington, D. C. In this connection the writer wishes to emphasize the following four important points that have a direct bearing upon control:

(1) It has been demonstrated that the boll weevil subsists on no other food than cotton.

(2) The weevil moves about but little until late in the cotton-growing season; in fact, not until the time when the crop is normally set.

(3) Winter conditions naturally reduce the number of weevils enormously; indeed, the winter is the critical period in the life history of the pest.

(4) Natural agencies operate to destroy a very large percentage of weevils. These agencies are increasing in effectiveness and already are of very great importance to the farmer in reducing his loss. Otherwise it would often be practically complete.

MEANS OF CONTROL.

It will be evident from the preceding statements regarding the life history and habits of the weevil that its control is beset with many difficulties. In fact, it is probably the most serious insect pest that is now known. Its insidious methods of work in the immature stages within the fruit of the cotton plant, the habit of the adult in seeking protection for the greater part of the time under the bracts of the squares, and its enormous power of reproduction and adaptability to new conditions, all tend to place the boll weevil in a class by itself. The difficulties are increased by the necessary procedures in raising cotton. In spite of these difficulties fairly satisfactory means of control are known. A large share of the reasonable success of the warfare against the pest is due to the assistance furnished by natural agencies, which commonly destroy many more weevils in a cotton field than the farmer could by any known method or methods.

Burning infested plants in the fall.—Foremost among the methods of control is the killing of the hordes of adult weevils that are ready to enter hibernation in the fall and the prevention of the development of millions more that would later emerge to pass through the winter. This is accomplished by burning the infested plants in the fall after the weevils have become so numerous that there is no prospect of the maturity of any additional crop. There are many vital reasons why the wholesale destruction of the weevils in the fall should be practiced by every cotton planter in the infested region. Some of these are stated below:

First. Hordes of adult weevils, many for each plant in the field, are killed outright.

Second. Many more weevils that are in the immature stages, possibly as many as a hundred for each plant in the field, are also killed.

Third. The few adult weevils escaping will be weakened by starvation and the great majority will not have sufficient strength to pass through the winter.

Fourth. The development of the late broods, which experiments have shown furnish the vast majority of weevils that pass through the winter, is cut off immediately. In this way hundreds of weevils that would develop from each plant are absolutely prevented from so doing.

Fifth. The removal of the infested plants with the weevils facilitates fall or early winter plowing, which is the best possible procedure in cotton raising. Moreover, this plowing assists greatly in the production of an early crop the following season.

In short, in the fall the weevil is at the mercy of the planter as it is at no other time. If the planter desires to kill the insect he can do so. Work in weevil destruction at that time far outbalances all remedial measures that may be applied at all other times of the year.

Many hundreds of cases are on record showing the benefit from the fall destruction of plants in the control of the boll weevil. The process has not been taken up as generally as it should, but individual instances everywhere show its value. A large amount of experimental work done by the Bureau of Entomology has all pointed clearly toward the supreme importance of this essential method in control. In an experiment performed by the Bureau of Entomology in Calhoun County, Tex., the stalks growing on 410 acres of land were destroyed early in October. Careful records kept during the following season showed that this work had increased the production more than a quarter of a bale per acre over the crop on the check area where such work was not done. Computing the increase in the crop at the current prices, the advantage from the work in the experiment amounted to $14.56 per acre. This was about 29 times the cost of uprooting and burning the plants, as shown by the amount actually paid by the Department for the work. Circumstances surrounding the experiment, referred to in Circular 95 of the Bureau of Entomology, show that the advantage was probably considerably greater than has been indicated here. At any rate, the estimate given is most conservative. In this instance the cotton destroyed was isolated and the results are perhaps somewhat more conspicuous than would have been the case where there were hundreds of cotton fields in the neighborhood. Nevertheless, experience with fields surrounded by others that have been given no attention has shown a great advantage from taking the proper step in the fall. Of course, concerted action will add to the effectiveness of the work and should be followed in every community.

In addition to the field work by the Bureau of Entomology and by many practical planters, a great deal of work has been done in large cages, where the conditions could be studied most carefully. In this way the exact relative advantage of fall destruction at different dates has been determined. It has been shown in this connection that the earlier the work can be done the better the results will be. For instance, seven times as many weevils survived the removal of the infested plants on November 12 as survived after similar work on October 13.

Mr. J. D. Mitchell, of the Bureau of Entomology, calls attention to a striking example of the value of the fall destruction of the weevils that came to his attention in 1908. On opposite sides of the Guadaloupe River near Victoria, Tex., were two farmers, each having about 40 acres in cotton. In one case the stalks were uprooted and burned in September, 1907, and in the other they were allowed to stand until shortly before planting time in the spring of 1908. They were equally good farmers, and the soil was the same on the two places. In the first case the crop of 1908 was 15 bales and in the other 3½ bales. The work done during the preceding fall plainly increased the crop about fivefold.

No definite rule can be laid down as to the proper time for destroying the weevils upon and in the fruit of the plants in the fall. In general, the proper time is whenever the weevils have reached such numbers as to infest practically all of the squares that are being set. This may occur a month or more earlier in some seasons than in others. Fall destruction as late as November will accomplish much, but several times the number of weevils can be destroyed if the work be done in October. Therefore the rule should be to destroy the infested plants at the earliest possible date in the fall. It is much better to sacrifice a small amount of cotton than to defer the operation. The loss will more than be made good by an increase in the next crop.

Some objections to the work of destroying the weevils in the fall are frequently raised. The principal one is that the labor supply is insufficient to enable planters to have the crop picked out in time for such fall destruction as is recommended.[a] One of the respects in which the boll weevil will make revolutionary changes in the system of producing cotton is that smaller areas than formerly must be cultivated by each hand. The production can best be kept up or increased by more intensive methods on smaller areas. If this principle be put in operation on plantations in so far as it is practicable, the objection to fall destruction on account of the scarcity of labor will tend to disappear. A minor objection raised is that the process tends to impoverish the soil. As a matter of fact, the burning of the stalks removes only a small amount of the fertilizing elements, and, moreover, the practice now is to burn the plants a few months later. In most cases the humus is more important than the fertilizing elements themselves. The use of commercial fertilizers in one case and the practice of green manuring in the other will solve both of these difficulties.

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[a] In this connection attention is directed to one of the many advantages of having the crop picked out early. The earlier this is done the cleaner the lint will be, and the better the price. Moreover, the longer the unpicked cotton remains in the fields the greater will be the amount that falls to the ground and soon passes beyond recovery. From every standpoint the cotton should be picked as rapidly as possible.

METHODS OF DESTROYING WEEVILS IN THE FALL.

The reader is referred to Circular 95 of the Bureau of Entomology for particulars regarding methods of destroying the weevils in the fall. In this connection it will be stated that the proper method, in general, is to uproot the plants by means of plows, and to burn them as soon as possible. Other methods are applicable to different conditions. As soon as the plants are uprooted they should be placed in piles or windrows, which will utilize the leaves in the burning. The difficulty in one method of removing the plants—that of cutting them off near the surface of the ground with a stalk cutter or ax—is that during mild seasons many sprouts soon make their appearance to furnish food for weevils that would otherwise starve during the fall or winter. If the ordinary stalk cutter be followed immediately by plows, some of the desired results will be obtained. The great objection is that the innumerable weevils in the bolls and squares will be allowed to develop. Nothing but uprooting and burning will come near meeting the exigencies caused by the weevil.

Grazing.—In some cases the grazing of the fields with cattle, sheep, or goats can be practiced. This is only a local measure, however, since the supply of live stock in regions where the bulk of the cotton crop is produced is insufficient for the purpose.

Sprout cotton.—A most important result of the proper manipulation of the plants in the fall is that no stumpage or sprout cotton is allowed to grow. The occurrence of such cotton in southern Texas and occasionally in southern Louisiana is there the most important local difficulty in the control of the boll weevil. Sprout plants are sometimes encouraged on account of the production of a small but very early crop. This may have been defensible before the advent of the boll weevil, but at the present time the practice is undoubtedly the worst that could possibly be followed. The sprout plants serve only to keep alive myriads of weevils that could easily be put out of existence by the farmer.

Volunteer cotton.—In addition to stumpage cotton, volunteer cotton, in the strict sense, is of considerable importance in weevil-infested areas. The seed scattered about seed houses and gins frequently give rise to plants, both in the fall and in the spring, that furnish food and breeding places for weevils. It is needless to call attention to the fact that all such plants should be destroyed. They are merely aids to the enemy.

DESTRUCTION OF WEEVILS IN HIBERNATING PLACES.

After the weevil-infested plants have been removed from the field in the fall the farmer can add strength to the blow he has given the insect. As has been stated previously, many of the hibernating weevils are not to be found within the cotton fields nor in their immediate vicinity. Nevertheless, most of those remaining in the field can be destroyed, and this is undoubtedly well worth the effort that it will cost. In many cases surprising numbers of weevils have been found hibernating in the trash and rubbish on the ground in cotton fields. In January, 1907, in one instance, 5,870 weevils per acre were found, of which 70 per cent were alive. This was undoubtedly exceptional, but most of the many examinations made showed more than 1,000 live weevils per acre in old cotton fields. The insects so found are largely at the mercy of the farmer. He can destroy many by carefully raking up the trash and burning it. Plowing and subsequent harrowing of the land will add to the destruction. This work would well be worth while on general agricultural principles if no weevils whatever were destroyed. With the weevil present, that farmer invites loss who does not clean the fields to the best of his ability.

Of the multitudes of weevils that fly out of the cotton fields for hibernation not all are beyond the reach of the farmer. Many are to be found along turn-rows, fences, hedges, and old buildings. The cleaning and burning of hedges, fence corners, and in general the removal of trash from the vicinity of fields will destroy many weevils that would live to assist in the destruction of the crop.

Old sorghum fields, on account of their roughness and the fact that the heavy stubble catches trash moved about by the wind, have been found to furnish very favorable winter quarters for the weevil. The farmer should pay special attention to such fields. They have frequently been found to be the source of the first weevils to damage the cotton in the spring. A little work in the fall or winter will result in the destruction of practically all of the weevils found there. Old cornfields, while not as important as sorghum fields, also furnish favorable hibernating quarters and should be carefully cleared by the farmer who desires to minimize the weevil damage on his place.

A very practical illustration of the danger of trash in aiding in the hibernation of the weevil has occurred repeatedly on the experimental farm of the Bureau of Entomology near Dallas, Tex. Across a narrow lane on one side of the experimental cotton field of 40 acres is a small peach orchard in which the weeds have been allowed to grow unchecked from year to year. Every season the first weevil infestation in the cotton is found in the immediate vicinity of the orchard. In fact, the infestation always starts at that point and radiates into the field. If it were possible to eliminate the hibernating quarters across the lane—and this means only the prevention of the growth of weeds—there would evidently be a considerable reduction in weevil damage, especially early in the season when it is most critical.

LOCATING FIELDS TO AVOID WEEVIL DAMAGE.

The illustration just given emphasizes a method of averting damage by the weevil that can be followed in many individual cases. All planters that have had experience with the weevil know that the portions of their properties near the timber or other hibernating quarters show the first damage by the weevil and consequently the least production. Of course, it is not always possible to plant other crops in such situations. Nevertheless, very frequently farmers can avoid damage by devoting the particular fields known to be most susceptible to weevil injury to other crops. This is not pointed out as a general recommendation. In many cases it would be entirely impracticable, but its importance should be realized by planters in regions where every possible precaution must be taken.

CROP ROTATION.

Save in very exceptional cases the boll weevil never does as much damage on land where cotton follows some other crop as on land where cotton follows cotton. This is due to the fact, as has been pointed out, that the weevils do not fly very far from their hibernating quarters in the spring. Therefore it is evident that a proper rotation of crops may be followed to assist in the fight against the boll weevil. As in the case of the location of the fields referred to above, the recommendation here made is no panacea. Nevertheless, rotation can be made to assist in fighting the weevil, aside from the many other advantages that are known to come from it.

PROCURING AN EARLY CROP.

Although the destruction of the weevils in the fall is the great essential step in controlling the insect, it can not be depended on exclusively. The full benefits of the fall work and the maximum crop can not be obtained unless the next great step, procuring an early crop, is also taken. In fact, the success of the farmer in producing cotton in regions infested by the boll weevil will depend directly upon the extent to which he combines the various methods described in this bulletin.

There are certain localities where the conditions cause the soil to be "late" or "slow." For instance, the planters on the Red River in

Louisiana state that they can procure early crops on their " front " land, but that such is difficult or impossible on the fields back from the river. This is largely a matter of drainage. In some sections in Louisiana and Mississippi the essential step in obtaining an early crop will be largely a question of drainage. Lands so situated that they can not be drained economically to the extent that allows an early crop must be devoted to crops other than cotton.

The advantage of early planting has been demonstrated in every one of the numerous experiments made by the Bureau of Entomology and has now become the general practice among farmers. The reasons for the efficiency of early planting are not far to seek. The small numbers of weevils passing through the winter must have considerable time to multiply. They are unable to breed until squares are put on by the plants, since the food obtained from the fruit is required before reproduction can begin. Moreover, at the time the first squares are put on, the development of the immature stages is comparatively slow, not reaching the very rapid rate that obtains during the warm days and nights of the summer. For these reasons it is possible for the farmer to rush his crop in such a way that a large number of squares and bolls will be formed before the weevils have multiplied to a serious extent. Of course, under usual conditions the weevils will ultimately multiply so that the crop put on after a certain date will all be destroyed. This, however, is of no importance, since a top crop in weevil regions is entirely out of the question. The time it takes the weevils to recuperate after the vicissitudes of winter, especially after the entirely feasible destruction of multitudes in the fall, can thus be taken advantage of in the production of a crop.

Removal of plants.—The first step in the procuring of an early crop is the early removal of the plants, so that the land may be plowed during the fall or winter and the seed bed given thorough and early preparation. In fact, such preliminary preparation should be followed for the production of the best cotton crop under any conditions. The recommendation made is therefore neither onerous nor revolutionary. The tendency has often been to neglect the cotton fields until spring or at least until " after Christmas." It would repay the farmer many times if he would take the slight additional trouble of plowing the fields before that time. Not only a plowing, but one or more harrowings should be given the land during the winter.

Use of commercial fertilizers.—An important step in procuring an early crop under many conditions is the use of commercial fertilizers.

In many large areas in the cotton belt the land is not impoverished to the extent that it actually needs fertilizers under normal conditions. It has been demonstrated many times by the different experiment stations in the South that the maturity of cotton can frequently be hastened materially by the use of fertilizers, especially those containing a high percentage of phosphoric acid. The recommendation for the use of fertilizers in weevil regions, therefore, does not imply the exhaustion of the soil. It merely means that fertilizers place in the hands of the farmers an important means of averting damage by the boll weevil. The proper use of fertilizers is a very complicated matter. In fact, in the light of all present knowledge only the most general rules can be laid down. Each farmer must experiment with the soil or different soils upon his own place and study the results to obtain the greatest benefit from fertilizers at the smallest cost. In the eastern portion of the cotton belt most of the farmers have acquired this experience. In the West, however, this training is lacking. Farmers interested should communicate with the State experiment stations and obtain the latest bulletins regarding experiments with fertilizers in their own regions.

Use of early varieties of cotton.—Next in importance to early preparation, and fertilization (where necessary), in obtaining an early crop of cotton comes the use of early varieties. In all experiments that have been undertaken the advantage in the use of early varieties has been conspicuous. As in other cases, the greatest advantage in this instance comes with the joint use of the other expedients recommended for weevil control. By far the best method for obtaining seed of early maturing cotton is for the farmer to carry on the selection himself. In many cases, however, this is impracticable. Under such circumstances the farmer should obtain seed of improved varieties from dealers or such individual farmers in the locality as have been able to carry on careful seed selection. A valuable publication on the selection of cotton varieties has been published by this Department as Farmers' Bulletin No. 314, "A Method of Breeding Early Cotton to Escape Boll Weevil Damage," by R. L. Bennett. A copy may be obtained by any planter by application to the Secretary of Agriculture.

Standard early varieties of cotton.—There are a number of standard varieties that have been found of value in weevil-infested regions the seed of which may be obtained from seed dealers. Among them are the Rowden, Triumph, Cleveland Big Boll, Cook's Improved, and King. All of these except the King have either medium-sized or large bolls. The King has a small boll, about 80 being required to make a pound, but is remarkably early and has given the best yields in most of the experiments of the Bureau of Entomology.[a] Hawkins' Early Prolific and Simkins have given good results in recent experiments of the State crop pest commission of Louisiana. In all cases it will pay the planter to exercise care in obtaining seed. Wherever possible it should be obtained from the originator.

Heavy cotton seed.—The Department of Agriculture has called attention to the advantage of planting heavy cotton seed (see Farmers' Bulletin No. 285). This should be taken into consideration along with other means of obtaining an early and vigorous stand. Another recent suggestion of assistance in obtaining an early start in the spring is that the planting be facilitated by covering the seed with paste. This method will make it possible to use an ordinary corn planter in putting in cotton seed and facilitate the work of check-rowing. This matter is discussed fully in the Farmers' Bulletin just referred to.

Early planting.—Another step to be taken in obtaining an early crop, and fully as important as those that have been mentioned, is early planting itself. Naturally no set rule can be laid down as to the proper date for planting. There is much variation in the seasons, and it is sometimes impossible to place the fields in readiness as early as is desirable. Much of the effect of early planting is lost unless the seed bed is in good condition. Rather than plant abnormally early it would be better to improve the seed bed. It is not recommended that planting be made at dangerously early dates. Nevertheless, with proper preliminary attention to the fields it would be possible for farmers in most localities to plant from ten to twenty days earlier

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[a] Some of the early maturing varieties of cotton happen to have small bolls, although the plant breeders hold that there is no necessity of an early maturing cotton having small bolls. In view of the fact, however, that some of the best known early maturing varieties at the present time have undersized bolls, occasional objections have been made to planting them. It is true that the picking of cotton from these varieties sometimes involves difficulties. In some cases it is known that pickers have refused to pick small-boll cottons while any other cotton was available despite the offer of additional payment on account of slow picking in the fields of the smaller bolled cotton. This is an actual, practical difficulty that must be taken into consideration. At the present time it is sufficient to call attention to the fact that the practical disadvantage of small bolls may not be as important as appears at first glance. For instance, if small-boll varieties yield 100 pounds of seed cotton per acre more than ordinary cotton, this gain would permit the farmer to pay 10 per cent more for picking, with profit. Thus:

750 pounds small-bolled cotton per acre picked at $1 per cwt., cotton at $3 per cwt., net profit	$15.00
650 pounds large-bolled cotton per acre picked at 90 cents per cwt., cotton sold at $3 per cwt., net profit	13.65
Difference in favor of small-boll cotton	1.35

than they are accustomed to at the present time. This, therefore, is the general recommendation that is made. It is much better to run the risk of replanting, provided the seed bed is in good condition, than to defer planting on account of the danger of cold weather. Of course it is possible to plant entirely too early, so that the plants become stunted during the early days of their growth. It is not intended that planting should be made early enough to have this effect upon the plants.

ADDITIONAL EXPEDIENTS IN HASTENING THE CROP.

It was pointed out in connection with the enemies of the boll weevil that under natural conditions a large percentage of the weevils is killed by heat and parasites. The wide spacing of the cotton plants augments the action of both these agencies working against the boll weevil. The effect of the sun heat has been studied in many cotton fields. The mortality becomes remarkably high during the hot days of summer. The farmer can take advantage of it, and even increase it. It is very conservative to state that the weevils will be able to multiply only half as fast in fields where there is plenty of distance between the plants as in fields where plants are close together and the branches cross from row to row. It should therefore be the rule of the planter in weevil regions to give considerably more distance to the plants in the drill and to the rows than he would give under ordinary conditions. On land that produces under normal conditions from 35 to 40 bushels of corn per acre the rows should be 5 feet apart. Even on poor soil it is very doubtful, except in dry regions of the West, whether the distance should ever be less than 4 feet.

Check-rowing.—Considerable attention has been attracted in some localities in Texas to the practice of check-rowing cotton to assist in the control of the weevil. Undoubtedly from this standpoint the practice is to be recommended highly. By following it each plant is given the maximum soil that it can use with consequent beneficial results upon its growth. The greatest possible amount of sunlight is allowed to fall upon the ground where the infested squares are found, to destroy many weevil larvæ outright and at the same time to facilitate the work of the numerous enemies of the weevil that occur in every cotton field. Check-rowing, moreover, saves much labor, thereby reducing the cost of production, and also makes easy the control of noxious weeds. The only important objection is that in some localities it may interfere with drainage.

Cultivation.—During the growing season of the crop the fields should be given very careful cultivations. Most of the benefits of early preparation, early planting, and fertilization may be lost in case the fields are not given the utmost attention subsequently. In case of unavoidably delayed planting the best course to pursue is to cultivate the fields in the most thorough manner possible. Under most conditions the old plantation rule "once a week and one in a row" should be made to apply. This will not result in the direct destruction of many weevils, but it causes the plants to continue uninterruptedly in their growth. By all means such operations as deep cultivation, and cultivation close to the plants, which causes shedding, should be avoided. In many instances a fair crop already set and beyond danger from the weevil has been lost by running the plows so close that the side roots were cut and the plants have shed practically all the fruit. When this happens during the middle or latter part of the season the weevils will certainly prevent the putting on of any more fruit. The general practice of laying by, by scraping the middles with a wide sweep, leaves a hard surface which causes loss of moisture and shedding. Where the weevil occurs, every precaution must be taken to avoid shedding, as the insect will certainly prevent the maturity of the later fruit and, moreover, will be forced to attack bolls which would otherwise not be injured.

Effect of late cultivation.—A very conspicuous illustration of the disastrous effects of careless late cultivation came to the attention of the Bureau of Entomology during the present season (1908). It was learned that some planters in the Red River Valley below Shreveport, La., were making fair crops (in one case 600 bales on 900 acres), while others were making very small yields as, for instance, in one case 200 bales on 800 acres. Upon investigation it was found that all the planters in the neighborhood were compelled to put all their hands on levee work for five weeks to save their places. During that time the cotton remained uncultivated. After the subsidence of the flood the fields were plowed. Where this work was done carefully the good crops were being produced. In cases where the plows were run too deeply and too close to the plants excessive shedding had taken place and the weevils prevented the putting on of any more fruit. Careful investigation on several places where the essential conditions were identical left no doubt that the cause of the difference in yields was primarily the difference in summer cultivation.

Occasionally a farmer is found who has obtained better yields on fields where cultivation has been discontinued early. In fact, the writer has seen fields full of grass that were outyielding perfectly clean ones on the same plantation. Such situations have caused erroneous conclusions. As a matter of fact, the explanation is that the late, careless cultivations had done more harm than good. The importance of careful shallow summer cultivations can not be too strongly emphasized.

SPECIAL DEVICES FOR DESTROYING WEEVILS.

The impression is more or less general that the only important way in which weevils may be killed is by the removal of the infested plants and that all other steps in the system of control are merely to avoid damage by the weevils that have survived that destruction, and their offspring. In spite of this impression, however, it is urged that the destruction of myriads of weevils can be accomplished during the growing season. This is to be done by working in cooperation with the natural agencies that destroy the weevil.

In making examinations of many thousands of infested squares from different localities and different situations in cotton fields it was found that mortality was conspicuously greatest where the sunlight was least obstructed and the heat, consequently, the greatest. The mortality in infested squares in the middles was many times as great as in the case of squares which remained under the shade of the branches. The temperature at the surface of the ground during warm days runs considerably higher than at a few feet above the surface. For instance, it was found that when the temperature was 100° F. in the regular Weather Bureau shelter about 4 feet above the ground the thermometer registered 140° F. on the surface. Likewise 90° F. in the shelter was accompanied by 120° F. on the ground and 85° F. in the shelter by 110° F. on the ground. It is not surprising, therefore, that the cotton squares that fall to the ground and are not shaded are very quickly baked, so that the weevils perish—if not from heat, then from the hardening of the food supply. In most cases they are simply roasted, their bodies assuming the appearance of larvæ that have been placed in a flame.

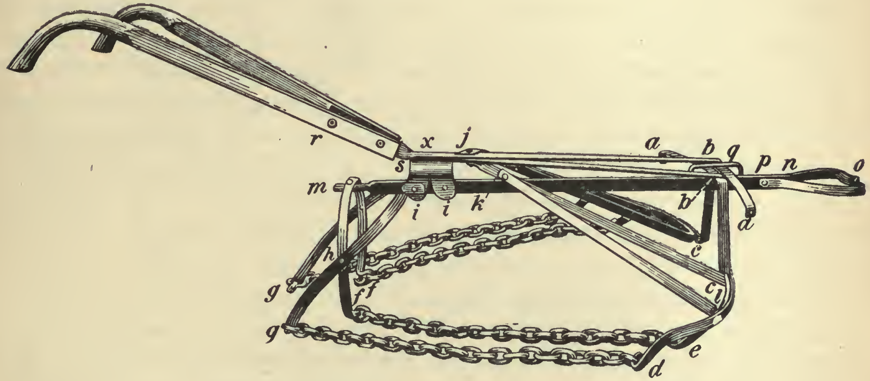

Fig. 6.—Chain cultivator, side view. (Original.)

Chain cultivator.—When the foregoing facts came to light efforts were made to perfect a device that would bring the infested squares out of the shade of the plants to the middles of the rows. After much experimental work one of the writer's former associates, Dr. W. E. Hinds, devised an implement that accomplishes the desired work in a satisfactory manner. This implement is known as the chain cultivator or chain drag.

The following specifications should enable any blacksmith to construct an effective chain cultivator. (See fig. 6.)

The draft bar (*n m*), made of $\frac{1}{2}$ by $\frac{5}{16}$ inch tire steel, about 52 inches long, is designed to be about 16 inches above the ground, and this is the height of the rear arch (*f h m*), which is of this size and form to allow old cotton roots, etc., to pass through freely without clogging at the rear.

The distance between the rear ends of the chains (*g g*, *f f*) is in each pair fixed at about 10 inches. The distance between a chain of one pair and that of the other at their front ends should be about 9 inches. The chains used are of the size known as "log chains," having short, close links of $\frac{3}{8}$-inch iron. This style of chain can be cut to the length needed in each case. The chain is easily attached by simply making the hooks at *d*, *e*, *f*, and *g* so that the end of the hook is as wide as will pass through the length of the link and narrow enough at the middle of the bend to allow the link to turn and bag the other way. So long as the chains are kept tight they can not become unhooked. The hooks should also be turned, or faced, in such a way that they will not be likely to catch the passing plants or rubbish.

The clevis (*o p*) is simply hinged, so that there will be no tendency to pull the front of the machine off of the ground, and it is also broad enough in front to allow of the point of draft being moved from one side to the other, so that the front of the machine may be thrown closer to one row if desired.

The front guard on each side (*a b c d*) is made of one piece of spring steel, $\frac{7}{8}$ by $\frac{3}{16}$ inch. This size seems sufficiently strong and best adapted to carry the tension of the chains (*d g*) while still yielding to the pressure against the bases of the plants as they may strike the outer, sloping ends near *d*. The inner ends of these guards (*a b*) are horizontal, about 18 inches each in length, and serve to carry the front guard above the draft bar (*n m*) and, passing through the keeper (*q*), guide in the adjustment for width. The machine can not be extended beyond the bent ends at *a* or closed beyond the angles at *b*. The vertical section between *b* and *c* is about 12 inches long, so that the remainder of the front guard from *c* to near *d* will be about 4 inches above the ground. This prevents the pushing of dirt and squares toward the plants and allows the chains to catch them where they lie. The hooks at *d* and *e* are therefore bent downward and somewhat backward through about 5 or 6 inches. Care must be taken especially in forming the outer ends between *c* and *d* to secure best results. The downward bend for the hook at *a* should not be abrupt, as a gradual slope helps to prevent catching on any obstacles. The hooks at *f* and *g* are formed so as to hold the chains firmly and yet not interfere with the passage of rubbish. The method of carrying the rear ends of the outer chains is shown at *i h g*. The piece *k l* is nearly parallel with the chains and may be used for their proper adjustment as to tension by several holes near the end where it is bolted at *k*. The chains are between 30 and 36 inches long. The stand *s* upon which the handles are pivoted by a ½-inch bolt is made of a piece of boiler plate bent and cut so as to have a horizontal top surface about 4 inches square and standing about 2½ inches above the draft bar, to which it is securely bolted. The handles are bolted, as at r, to the heavy pieces of iron (about 2 by ½ inch tire steel) which are bent to receive them just behind the pivotal point at *x*, at such an angle as to bring the handles to the proper height and position. In front of *x* these pieces bearing the handles need not be so heavy and may therefore be tapered and welded to smaller steel running forward to *b*, where it is bolted to the front guard. The operation of this arrangement is similar to that of a huge pair of shears—when the handles are pushed apart the front of the machine is spread wider, and vice versa. The braces *j c e* serve to support, strengthen, and carry the front guard. They are riveted to the adjusting irons at *j*, one above and one below the "shear" pieces, to prevent their interference with the closing of the machine. At *c* this iron is bent to conform to the front guard, to which it is riveted between *c* and *l*, at which point it is bent downward and forms the hook *e*. Ordinary tire steel about 1 by ¼ inch may be used for all parts like the clevis (*o p*), rear arches (*f h m* and *i h g*), and braces (*k l* and *j c e*). The front guard (*a b c d*) should be of spring steel, as specified. The rivet heads on the front guard should be round and fit smoothly. In nearly all other places the irons are fastened together by ¼-inch square-headed bolts, with washers as needed.

In operation the implement is drawn by a single animal. The chains at *d* and *e* pass under the branches of plants and close to the stems. The forward motion of the machine causes these squares to be drawn inward by the chains, which must be kept taut, and leaves them in a narrow pathway where the chains approach within a short distance of each other at the opposite end of the machine. (See figs. 7, 8.) The two chains are provided so that squares that may pass over the first are taken up by the second on either side. In actual practice it has been found that more than 90 per cent of squares may be brought to the middle of the rows. This means that the natural mortality among the weevils due to the effects of sunshine can be at least doubled.

Although the chain cultivator was designed primarily for bringing the squares to the middles, it was found in field practice to have a most important cultural effect. The chains (so-called "log chains") are heavy enough to establish a perfect dust mulch (see figs. 7 and 8) and to destroy small weeds that may be starting. In fact, it is believed that this cultural effect would more than justify the use of the machine, regardless of the weevil. With the effect against the insect and the important cultural effect it is believed that this implement or one similar to it should be used by every farmer in the weevil territory.

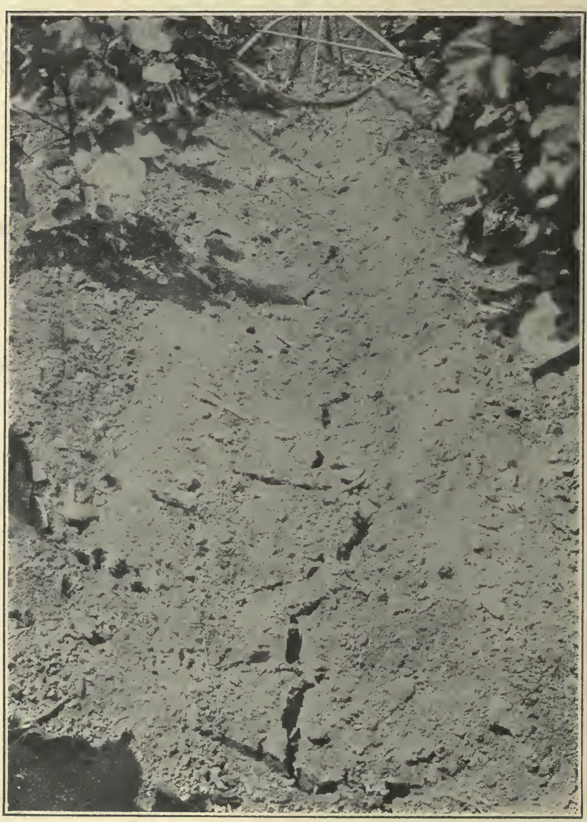

FIG. 7.—Work on the chain cultivator: Cotton row before use of cultivator, showing fallen squares, crack, and rough condition of ground. (Original.)

In order that the use of this machine could be obtained by all farmers at the smallest possible cost, a patent has been taken out in the name of the Department of Agriculture and for the benefit of the people of the United States. Under this patent it is impossible for anyone to manufacture the machine exclusively and to charge unnecessarily high prices.

Attachments for ordinary cultivators.—Some of the effects of the chain cultivator may be obtained by attaching chains to ordinary cultivators by the use of special attachments. In this way some of the effect of the chain drag would be added to the work of the cultivator. Wherever for any reason it is impossible to obtain chain drags, it is suggested that the principle be incorporated in some simple attachments to cultivators.

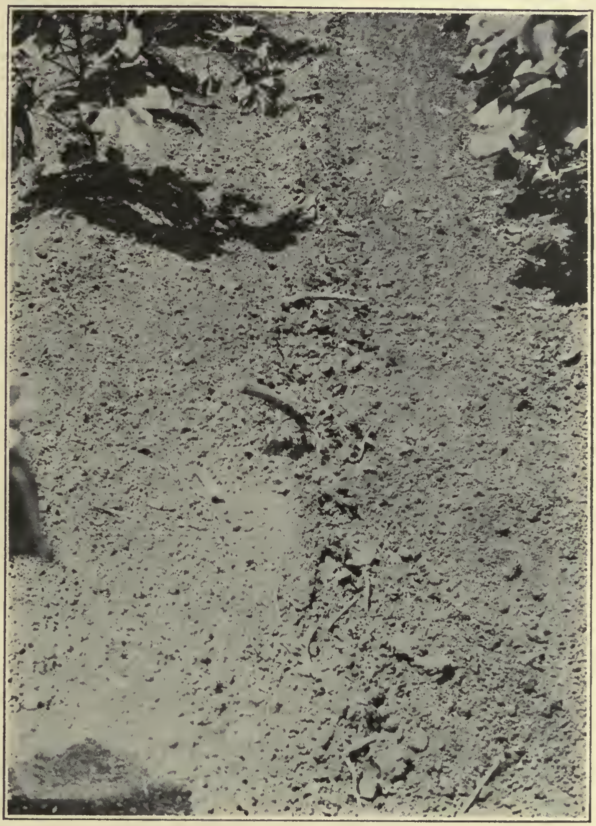

Fig. 8.—Work of the chain cultivator: Same row shown in fig. 7, after cultivator has passed; majority of squares brought to middle, crack filled, and dust mulch established. (Original.)

The use on ordinary cultivators of an arm or projection that will brush or agitate the plants in passing will assist to a certain extent in destroying the weevil. The squares will be knocked to the ground earlier than they would fall, and this would naturally increase the effect of heat. At the same time a very few adult weevils will be knocked to the ground, but this has been found to be unimportant. In repeated experiments in jarring and beating cotton plants on which known numbers of weevils were found it was ascertained that very few, if any, left the plants by reason of any agitation that would not break the branches or bark the stems. Occasionally, however, a weevil passing over a leaf is jarred to the ground. Often entirely too much stress is placed upon the importance of jarring the adult weevils to the ground. When specimens are collected by hand and thrown on the surface of the ground, especially if it be finely pulverized, the great majority will be killed almost instantly by the heat. This has caused the mistake on the part of careless observers of supposing that many weevils could be killed by jarring them to the ground. The difficulty, as pointed out, is that it is totally out of the question to jar more than one weevil out of many hundreds to the ground by any process that would not injure the plants severely. Nevertheless, the effect of a cross-arm of wood or iron whipping through the tops of the plants is recommended for the reason that the squares are thrown to the ground, where the heat has its earliest possible effect upon them.

HAND PICKING OF WEEVILS.

Gathering the weevils by hand is an operation of limited applicability. Where the fields of cotton are small and there is an abundance of labor it is sometimes practicable to pick the early emerging weevils from the plants and later to pick up the early fallen squares. Everything depends, however, on the conditions being favorable. On large places it will undoubtedly not often be found practicable to carry on this process. In an experiment performed by the Bureau of Entomology on a plantation worked by convict labor, giving the optimum conditions for the experiment, no results whatever followed thorough pickings twice each week for two months in the spring, beginning with the appearance of the first weevils. In another instance, at Gurley, Tex., more than 40,000 weevils were picked on an area of 8 acres by means of paid labor, beginning in April and continuing until July. On the 8 acres where this work was done a crop of about 50 pounds per acre in excess of that on other areas was obtained. This was not sufficient, however, to pay for more than a very small fraction of the work done. From these and other experiments the Bureau of Entomology recommends in a guarded manner the picking by hand of weevils and squares. Undoubtedly good may be accomplished under certain conditions, but planters should be careful not to depend too much upon it and not to make too great an outlay for it.

Disposition of adult weevils and infested squares.—When adult weevils are picked by hand they should be killed by means of oil or fire, or buried deeply in the ground. When infested squares are picked, however, an entirely different procedure should be followed. Many of the weevil larvæ in the infested squares will be found to harbor parasites. It is entirely practical, as has been pointed out by Mr. Wilmon Newell, of the Louisiana crop pest commission, to let these parasites develop and continue their work against the weevils in the fields. This is done simply by placing the infested squares in wire cages. The parasites, on account of their small size, will escape, while the weevils soon die from a lack of food. The meshes of the wire of the cage should be at least 16 to the inch. However, some weevils will escape through this mesh, and about 5 per cent through a 14-mesh screen. Even if the finer wire can not be obtained, it is advisable to use what can be had. A calculation will show that there is a direct advantage even if a few of the weevils escape, if all of the parasites do. By burning or destroying the squares in any other way the farmer is simply working against and counteracting an agency in the control of the weevil that is much more important than any amount of hand picking he is likely to be able to do.

TOPPING OF PLANTS.

The practice of topping plants is sometimes recommended for fields infested by the boll weevil. The results of work by different experiment stations have shown that topping has exceedingly uncertain general results. As often as otherwise it decreased instead of increased the crop. In any case the topping of plants can probably do no harm in fields that are being damaged by the weevil. It is probable that the general results will be beneficial in causing the more rapid growth of the crop on the lower and middle branches. It has never been possible to demonstrate this in an exact way. Nevertheless, for the general effects stated the topping of plants is included among the recommendations that should be followed, although as one of minor importance.

COTTON LEAF-WORM AND BOLL WEEVIL.

The relation between the formerly dreaded leaf-worm or so-called "army-worm" and the boll weevil deserves special attention. A quarter of a century ago the efforts of entomologists and planters were directed toward some means of destroying the leaf-worm. The use of Paris green was found to be effective. Various changes in the general system of cropping cotton also caused the injuries of the leaf-worm to become less conspicuous year after year. Even up to the time of the spread of the weevil into Texas, however, poisoning was a more or less regular operation on all cotton farms. The insects never did any considerable damage before the middle or latter part of the season. The object in destroying the leaf-worm was that it prevented the maturity of a fall crop. For this reason the saving of the top crop and in exceptional seasons a part of the middle crop was all that was desired. The work of the boll weevil has changed all this. After the careful studies that have been given the problem it is evident that no top crop of cotton can be expected in infested regions. This, of course, reduces the leaf-worm to an insect of no importance where the boll weevil exists.

The change has actually been even greater than this, for the work of the leaf-worm has a disastrous effect upon the boll weevil. As has been pointed out in the discussion of fall destruction, the late developing weevils are the ones that pass through the winter. Consequently, if the leaf-worms defoliate the plants and stop the formation of squares, a certain degree of fall destruction is accomplished. It can never be as satisfactory as the poorest artificial fall destruction, because the plants continue to leaf out after the defoliation by the worms, thus giving the weevils a supply of succulent food. It is not recommended that the work of the leaf-worm be depended on in place of fall destruction. Nevertheless, allowing the leaf-worms to proceed with their work, or even encouraging them, will assist as a general procedure against the boll weevil at least when, for any reasons, the more important steps are not taken. In some cases where the injury by the leaf-worms begins unusually early, it may still be advisable to check it by poisoning in the well-known manner, but save in such exceptional circumstances it will now be better to allow the leaf-worm to work unrestrictedly.

It has been suggested by Mr. Wilmon Newell that in special cases where there are difficulties in the following of the fall destruction of the plants, it may be advisable to take means to encourage the leaf worm. This could be done by breeding larvæ and pupæ to be scattered in the fields and by carrying the pupæ from localities, as the hills, where they appear first, to the valley fields, which are normally not reached until some time later.

DESTROYING THE WEEVIL IN COTTON SEED.

It has been abundantly shown that cotton seed is of importance as a medium through which the weevil may be carried. Many individuals that happen to be carried to the gin on the cotton pass uninjured through the gins to the seed houses. Consequently every seed house connected with a gin in the infested territory harbors more or less weevils, depending upon the amount of cleaning the staple is given. Of course such seed is exceedingly dangerous when taken into uninfested regions. Undoubtedly the present absolute embargoes against cotton seed from the infested region are wise. In general, they should be strictly construed. In some special cases, however, when, for instance, it is desired to obtain special improved seed, proper precaution can be taken to destroy all weevils by means of fumigation with carbon bisulphid. The method was described by the writer in Farmers' Bulletin 209, from which the following is quoted:

> The following plan for this work is proposed: A tight matched-board box should be provided having sides 4 feet high, open on top, and of other dimensions to accommodate 12 or more 100-pound sacks of cotton seed placed upright upon the bottom. Another tier of sacks could be added if desired. Into each one of these sacks about 1 ounce of carbon bisulphid should be forced by an apparatus for volatilizing the liquid and mixing the vapor with air. The accompanying illustration (fig. 9) will give an idea of this apparatus. It should consist of three essential parts, as shown in the illustration. *A* is an air pump having sufficient storage capacity to enable it to maintain a steady discharge of

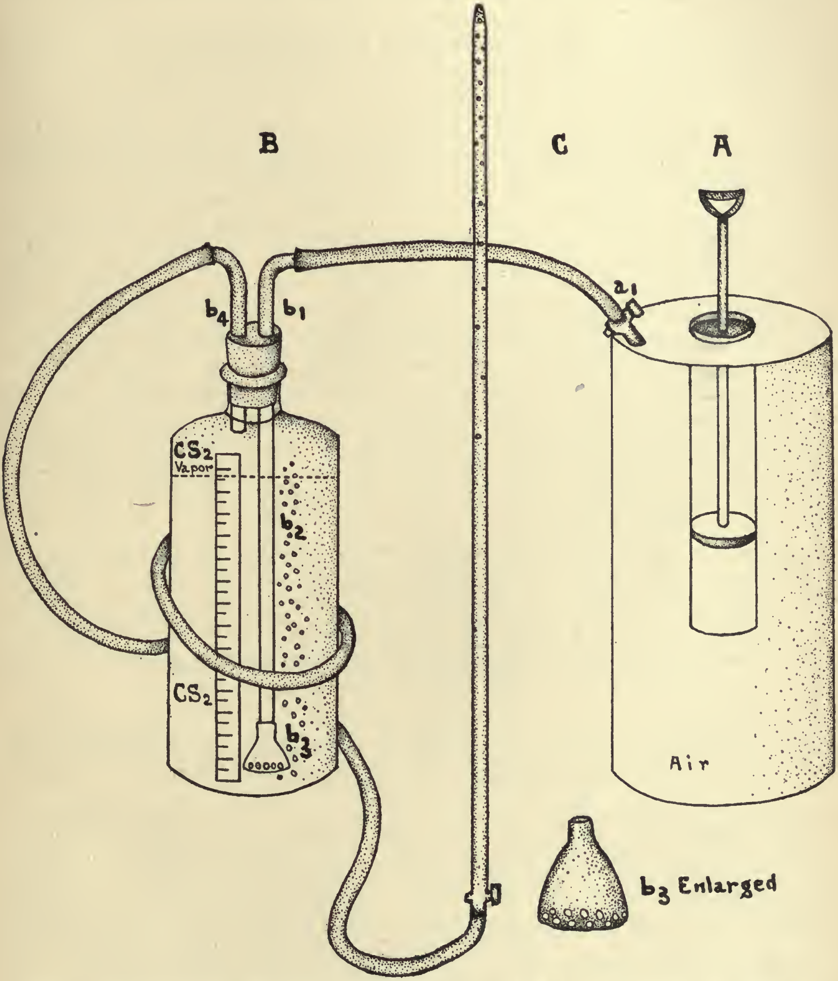

FIG. 9.—Apparatus for fumigating cotton seed in the sack. (Author's illustration.)

air for several minutes without continuous pumping. The stopcock at a_1 regulates or prevents the escape of air, as may be desired. *B* is an ordinary 2-quart bottle fitted at b_1 with a tight stopper of good length, having two openings, through which the inlet and outlet pipes pass. These pipes may be of glass or metal and should be as large as can be used. The inlet pipe, b_2, reaches nearly to the bottom of the bottle and is provided at the lower end with a perforated metal cap as large as will pass through the neck of the bottle. This allows the escape of the air in small bubbles and insures rapid evaporation. The outlet pipe, b_4, reaches only through the stopper. Upon the outside of the bottle is pasted a paper marked with 1-ounce graduations. *C* is a piece of ordinary ⅜-inch iron gas pipe about 3½ feet long, but this may be any desired length. It is closed and roundly pointed at the tip, and for about 15 to 18 inches of its length provided with small perforations pointing in all directions to give free escape to the vapor into all parts of the sack of seed at once.

The connections may be of rubber tubing, but as little rubber as possible should be used for this apparatus, as it is affected by the vapor of the bisulphid, and the couplings will have to be frequently replaced. This, however, will not be a considerable item of expense. With the apparatus just described one operator would be able to accomplish the entire work of disinfection. The amount of carbon bisulphid recommended is about 1 ounce for each 3-bushel sack. It is safe to say that this can be secured for less than 1 cent per ounce when purchased in 25 or 50 pound lots, making the cost of bisulphid not over 1 cent per sack. As it requires but from two to three minutes to vaporize 1 ounce of the liquid in the manner described, the expense for labor in application would not amount to one-half a cent per sack. Fumigation with carbon bisulphid can therefore be effectively made at the slight expense of from 1 to 1½ cents per 100-pound sack.

Application of the bisulphid in this manner reduces the elements of danger to a minimum, as the vapor is almost wholly confined and the slight quantity escaping, mixed with the open air, would not be in either inflammable or explosive proportions. It has been determined that the slight trace of bisulphid vapor in the air would not injure the operator in the slightest degree. The sacks should be left in the box for forty hours after the gas is injected.

RELATION OF MEANS OF CONTROLLING THE BOLL WEEVIL TO THE CONTROL OF OTHER INSECTS.

The cotton bollworm.—The most important insect enemy of cotton in the United States, aside from the boll weevil, is the bollworm. This pest has existed in this country for many years and frequently reduces the crop very considerably. The annual damage to cotton in the United States has been conservatively estimated at over $8,000,000. In addition to the injury to cotton this insect is a very important enemy of corn, tomato, okra, cowpeas, and some other crops. Careful studies of the bollworm were conducted by Mr. A. L. Quaintance, of the Bureau of Entomology, in connection with large-scale field experiments in many localities. The conclusions drawn from this practical work were that the essential steps to be resorted to in the control of the boll weevil are exactly the ones that should be followed in the warfare against the bollworm. The following is the statement by Mr. Quaintance on this subject:

> The steps in the production of early cotton, outlined above, include the principal recommendations for the growing of cotton in the presence of boll weevils. It is therefore seen that injury from the cotton bollworm and the cotton boll weevil may be best avoided by the adoption of one and the same course of improved farm practice. The spread of the latter species will render imperative the adoption of these methods in profitable cotton culture, and along with this change the ravages of the bollworm during normal seasons should become less and less.

The cotton aphis.—Of the numerous minor enemies of the cotton plant in the United States there is one, the cotton aphis, or plant-louse, that may occasionally cause unusual damage by reason of early planting. This will only happen to any appreciable extent during wet seasons. Under such conditions the aphis may sometimes make it necessary to replant.[a] Nevertheless, this is not an important difficulty. It is not of sufficient moment to be considered at all, in view of the enormous benefit in avoiding damage by the boll weevil by means of early planting. If the other steps in the control of the boll weevil be taken and the fields made clean during the winter and the rubbish in the fence corners and along the turn-rows destroyed, it is not likely that the aphis will do any considerable damage, even during the coolest and wettest springs.

The injury inflicted by several other insects, such as the cotton square borer, webworm, and cutworms often makes the crop somewhat later, and consequently likely to be injured by the weevil.

GENERAL CONTROL THROUGH QUARANTINES.

There is no doubt whatever that the weevil can not be prevented from extending its range to the extremes of the cotton belt in this country. However, the damage is so great and the disturbance of economic conditions so extensive that all reasonable precautions should be taken to prevent the early accidental importation of the weevil to uninfested regions. Practically all of the States in the cotton belt have enactments designed to this end. Undoubtedly they should be enforced to the fullest extent.

At one time considerable inconvenience was caused the shipping interests by the lack of uniformity of quarantines in different States and the inclusion of articles in which there is very little danger. At the present time these difficulties have largely been removed. All that it is advisable to include in the absolute quarantines are cotton seed, seed cotton, cotton-seed hulls, and baled cotton. These commodities are likely to carry the weevil with them. In fact, it has been amply demonstrated that the insects are frequently carried in this way. Other articles, and even empty cars, may occasionally transport weevils, but the degree of danger is so much less than in the cases of the articles specified above that they do not need to be taken into consideration.

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[a] On the contrary, cases have been noticed where early breaking and thorough working caused a lessening in the number of aphides, due to the destruction of the ant that protects them. Mr. Wilmon Newell calls our attention to an instance of this kind in Louisiana in 1908.

It is entirely feasible to eradicate small isolated colonies of the boll weevil. An important office of the State authorities, concerned in State quarantines should therefore be to investigate reported outbreaks of the weevil and be prepared to take the necessary steps toward eradication at the earliest moment. The Bureau of Entomology will assist the state authorities in any cases of this kind.

ATTEMPTS TO POISON THE BOLL WEEVIL.

From the very beginning of the fight against the boll weevil attempts have been made to poison it. In 1894 and 1895, in the region originally infested in Texas, agents of the Bureau of Entomology conducted careful experiments with poison. Since that time various advocates of poisons have appeared. The idea appeals so strongly to farmers that these advocates have sometimes enlisted considerable followings. This has made it necessary for the Bureau of Entomology to carry on a large number of special investigations relating to poisons. In order to understand the difficulty of poisoning it must be remembered that during the growing season the boll weevil feeds only by inserting its beak deeply into the squares or bolls. It is therefore entirely out of the question to place the poison in a position where the insect will feed upon it.

Early in the season, however, before any squares are formed, the hibernated weevils that may have emerged feed upon the opening leaves on the so-called bud of the young cotton plant. At this time it is possible to destroy a considerable percentage by the application of poison. In all experiments performed in the field by the Bureau of Entomology very heavy applications throughout the season from chopping to picking have failed to show any advantage in the use of poison. Even light applications have been found to have insidious injurious effects upon the plants. The reason for the ineffectiveness of poisons is that the great majority of the weevils do not emerge from hibernating quarters until after the squares have begun to be formed. The destruction of some of the early emerging individuals does not prevent the remainder from causing complete infestation of the fields at the usual time.

Arsenate of lead.—Recently Mr. Wilmon Newell, of the State crop pest commission of Louisiana, has published a preliminary report regarding experiments with powdered arsenate of lead as a poison for the boll weevil. This substance has the advantage of being absolutely harmless to the plants, whereas Paris green applied to the tender terminal growth frequently causes the plants to become stunted, to remain so throughout their lives. Although the powdered arsenate of lead has this advantage, the question still remains as to whether enough weevils can be poisoned to result in any special benefit to the crop. The following is Mr. Newell's statement on this subject:

> As it is, the profit to be derived from applying the powdered arsenate of lead when the cotton is in the budding stage can only be determined by actual tests in the field, in which the production of poisoned and nonpoisoned cotton (both under conditions otherwise exactly alike) is carefully determined.

It will be noted from Mr. Newell's statement that no field experiments have been carried on to determine whether any direct benefit can be obtained from the use of powdered arsenate of lead. The Bureau of Entomology therefore urges that until further notice no farmers go to the expense of attempting to poison the boll weevil in any way.

Many attempts have been made to cause poisoned substances to be attractive to the weevil by introducing sweets and other ingredients. All these have failed completely. Some known sweets, such as honey, have a slight attraction for the weevil, but not enough to assist in practical control even regardless of their expense.

Contact poisons.—Poisons designed to kill the weevil by suffocating rather than by being taken into the digestive organs, have been proposed. They can not, of course, be effective against the immature weevils within the cotton fruit. The difficulties in reaching the adults are in their manner of work. Normally these insects are found inside the bracts of the squares, where they can not be reached by sprays. In fact, nature designed the bracts to prevent the heaviest rains from reaching the square within. An additional difficulty is in the expense of applying sprays, not only on account of labor, but on account of the special machinery that is necessary. Although there is some very remote possibility that dry poisons may be found of assistance in controlling the weevil, on account of the facts mentioned it is not at all probable that liquid sprays can ever be used.

Effect of confinement.—There is one peculiarity of the weevil that has led to many unwarranted claims as to the efficacy of remedies. The insect will die within a very short time when confined in a bottle or jar or even in a cage. Even when cages are placed over growing plants it is found that numbers of the insects die and fall to the ground, though no poison has been applied. In many instances experimenters have applied their preparations under such conditions and have found dead weevils later. They have made no allowance for the weevils that would have died under these conditions without any treatment whatever. In such experimental work special pains should always be taken to provide one or more careful checks upon the weevils that have been subjected to treatment.

FALSE REMEDIES.

The extreme seriousness of the boll-weevil problem has called forth many hundreds of suggestions in control. These have covered such methods as changes in manner of planting, attracting the insects to food plants or lights, soaking the seeds to make the plants distasteful, sprays, machines, smokes, and the planting of various plants supposed to be repellent. In many cases these suggestions have been made without due understanding of the habits of the weevil. In other cases practical features, such as the cost of application, have not been considered. The following paragraphs deal with some of the principal fallacious methods that have been proposed.

Late planting.—Foremost among the futile means of control is late planting. At various times different persons have suggested that late planting, especially if following early fall destruction, would so lengthen the hibernating period that no weevils would be permitted to survive. Very numerous experiments in the field and in cages have proved that the weevils in considerable numbers are able to survive from any reasonable time of early destruction in the fall to beyond the date in the spring when any return whatever could be expected from planting cotton, even if the weevils were entirely eliminated. In a field experiment performed in Kerr County, Tex., the plants were removed very thoroughly early in November. No stumpage or volunteer plants were allowed to grow during the winter. There was no other cotton planted within 9 miles. On the experimental field planting was deferred until June 10. In spite of this fact weevils appeared as soon as the plants were up and multiplied so rapidly that the production was not sufficient to warrant picking. A similar experiment was carried out under different conditions by the State crop pest commission of Louisiana and the results published in Bulletin 92 of the Louisiana Experiment Station. The results obtained in Louisiana agree in every way with those obtained by the Bureau of Entomology in Texas.

The reasons for the failure of late planting are evident from a study of the habits of the insect. In many cage experiments it has been found that the last emerging weevils in the spring appear well into the month of June. In fact, emergence has taken place as late as the 27th and 28th of June. Without any food whatever the emerging weevils are able to survive for some time. The maximum known survival of any hibernated weevil without any food whatever after emergence was 90 days and a considerable number lived from between 6 to 12 weeks after emergence. This ability to survive without food, together with the late emergence, render it entirely out of the question to exterminate the boll weevil by late planting. Moreover, there are always to be found along roads, turn-rows, in cotton fields, and elsewhere, a considerable number of volunteer plants which come from seed scattered accidentally or blown from the bolls during the fall. These plants, starting early in the spring in such numbers as to be beyond control, would furnish a means for the weevils to subsist to the time of planting, regardless of how late it might be. In 1906, for instance, at Dallas, Tex., it was found that volunteer plants appeared in the spring at the rate of about 1,000 per acre. An investigation showed that the number of such plants increases to the westward as the climate becomes drier. Nevertheless, numbers of plants were found near Memphis, Tenn., and Vicksburg, Miss., in a region of more than 50 inches of annual precipitation.

Trap-rows.—The idea of attracting weevils to a few early plants or trap-rows seemed hopeful at one time. Practical work in the field, however, has shown that nothing whatever can be expected from this means. The difficulty is that the early plants exert very little attraction. Moreover, before the majority of the weevils have emerged from hibernation the planted cotton is always large enough to furnish them plenty of food. In practice it has been found impossible to defer planting long enough to concentrate any appreciable number of weevils on the trap plants. Trapping weevils to hibernating quarters is an equally mistaken idea. They can not be induced to resort to any particular places. It is likewise impossible to attempt to make the cotton fields more favorable for hibernation than places outside of the field.

There is one way in which trapping may occasionally be resorted to with good effect. When the plants are destroyed in the fall and the weather is so warm that the majority of weevils have not entered hibernation, many of them will be found upon the plants that are left. Under these conditions the farmer can leave a few trap-rows to good advantage. They should be uprooted and burned within ten days of the time the other plants are destroyed, to kill the weevils that may be found upon them. Hand picking at frequent intervals before destruction may be practicable where labor is inexpensive.

Attraction to lights.—Many insects more or less resembling the boll weevil are attracted to lights. This has caused many persons to attempt to destroy the cotton pest by taking advantage of the supposed habit. It has been found, however, that the boll weevil is not attracted to lights to any extent whatever. In one experiment a number of strong lanterns were placed in cotton fields in Victoria County, Tex. In all, 24,492 specimens of insects were captured, representing about 328 species. Of these, 13,113 specimens belong to injurious species, 8,262 to beneficial species, and 3,111 were of a neutral character. Not a single boll weevil was found among all these specimens, notwithstanding the fact that the lights were placed in the midst of fields where there were millions of these insects.

Chemical treatment of seed.—It is scarcely necessary to call attention to the fallacy of attempting to destroy the boll weevil by soaking the seed in chemicals in a hope of making the plants that are to grow from them distasteful or poisonous to the insect. Any money expended by the farmer in following this absurd practice is entirely wasted.

Other proposed remedies.—Many remedies for the destruction of the weevil, consisting of sprays, poisons, and fumigants or "smokes," have been proposed. Hundreds of these proposed remedies have been carefully investigated. The claims of their advocates in practically all cases are based upon faulty observations or careless experiments. The strong tendency of the weevil to die in confinement, which has been referred to, has caused many honest persons to suppose that the substances they are applying have killed it. Moreover, an insuperable difficulty that these special preparations have encountered is the impracticability of the application in the field. Hundreds of known substances will kill the weevil when brought in contact with it. The difficulty is to apply them in an economical way in the field. A striking instance of the unwarranted claims of some discoverers of "remedies" for the weevil was the case of a man who demonstrated the efficacy of his preparation by placing a feather in the bottle containing it and applying this to a weevil in his hand. Of course the death of the weevil was very far from a demonstration of the practical working of the supposed remedy. On account of the many difficulties in reaching the weevil and the necessity of obtaining special machinery for applications of poisons or sprays in the field, it is now considered, after much careful experimentation, that there is only the remotest hope of any such substances being of any practical avail whatever in the fight against the boll weevil. The claims made at different times of the repellent power of tobacco, castor-bean plants, and pepper plants against the boll weevil have no foundation whatever. In fact, none of these plants has the least effect in keeping weevils away from cotton.

Mechanical devices.—Many machines have been constructed to collect the weevils from the plants, or the bolls and squares from the ground. These have consisted of suction and jarring devices. Many of them will destroy a certain number of weevils, but the habits of the insect are such that none has been found to yield results that pay even a small portion of the cost of operation. It is emphasized in this connection that there are plenty of proper ways in which all available mechanical ingenuity may be utilized in the fight against the weevil. There is great need for effective machines for assisting in the destruction of the weevils in the fall, and also for assistance in the cultivation of the crop. The present implements for cultivation, while effective in their way, could be improved in many respects, especially for the purpose of hastening the maturity of the crop. For instance, cultivators like the chain-cultivator mentioned in this bulletin, to establish a dust mulch rather than to plow the ground, are much needed. There are some cultivator attachments, such as the spring-tooth attachment, which are exceedingly useful tools in maintaining a surface dust mulch, but these are not as yet in general use.

SUMMARY.

The following is an outline of the practical methods of controlling the boll weevil described in detail in the preceding pages. These methods are based upon extensive studies and much field experimentation. They represent practically all that is known about combating the most important enemy of the cotton plant. They form a system consisting of several parts. The planter can insure success in proportion to the extent to which he combines the different essential parts.

(1) Destroy the vast majority of weevils in the fall by uprooting and burning the plants. This is the all-important step. It results in the death of millions of weevils. It insures a crop for the following season.

(2) Destroy also many weevils that have survived the preceding operation and are found in the cotton fields and along the hedgerows, fences, and buildings. This is done by clearing the places referred to thoroughly. (See pp. 22–23.)

(3) As far as possible, locate the fields in situations where damage will be avoided. This can not be done in all cases but can frequently be done to good advantage.

(4) Prepare the land early and thoroughly in order to obtain an early crop. This means fall plowing and winter working of the land.

(5) Provide wide rows, and plenty of space between the rows and the plants in the drill, for the assistance of the natural enemies of the weevil, which do more against the pest than the farmer can do himself by any known means. Check-rowing, wherever practicable, is an excellent practice.

(6) Insure an early crop by early planting of early-maturing varieties, and by fertilizing where necessary.

(7) Continue the procuring of an early crop by early chopping to a stand and early and frequent cultivation. Do not lose the fruit the plants have set by cultivation too deep or too close to the rows.

(8) Where the labor is sufficient, pick the first-appearing weevils and the first-infested squares. Do not destroy the squares but place them in screened cages. By this means the escape of the weevils will be prevented, while the parasites will be able to escape to continue their assistance on the side of the farmer. (See pp. 34–35.)

(9) Use a crossbar of iron or wood, or some similar device, to cause the infested squares to fall early to the ground, so that they will be exposed to the important effects of heat and parasites.

(10) Do not poison for the leaf-worm unless its work begins at an abnormally early date in the summer.

(11) Do not go to the expense of buying special preparations for destroying the weevil. Disappointment and loss is certain to follow. In case of doubt communicate at once with the Bureau of Entomology or with the entomologist of the State experiment station.

SPECIAL TREATMENT OF SMALL AREAS.

In some cases, where, for instance, a farmer has a small area of cotton growing for seed selection, it is practicable to resort to special means of control that would be impossible in general field practice. For the benefit of the many farmers in the infested area who are beginning to improve their cotton by selection, the following suggestions are made: The plat or plats should be far from timber, hedgerows, seed storage houses, and other protection for hibernating weevils. On the appearance of the earliest weevils the plats should be carefully picked over by hand. This should be continued until well after the squares begin to fall. If the falling of the squares continues it will be found practicable to rake them by hand to the middles or entirely outside of the plats to a bare place, where the sun will soon destroy the larvæ within. Of course all other general suggestions that are applicable in the field should be added to these special ones.

FARMERS' BULLETINS.

The following is a list, by number, of the Farmers' Bulletins available for distribution. The bulletins entitled "Experiment Station Work" give in brief the results of experiments performed by the State experiment stations. Titles of other bulletins are self-explanatory. Bulletins in this list will be sent free to any address in the United States on application to your Senator, Representative, or Delegate in Congress, or to the Secretary of Agriculture, Washington, D. C. Numbers omitted have been discontinued, being superseded by later bulletins.

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24. Hog Cholera and Swine Plague. Pp. 16.
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FARMERS' BULLETIN 345.

SOME COMMON DISINFECTANTS.

BY

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Animal Industry,
Washington, D. C., December 2, 1908.

Sir: I have the honor to transmit herewith the manuscript of an article entitled "Some Common Disinfectants," and to recommend the publication of the same as a Farmers' Bulletin.

Very respectfully,

A. D. Melvin,
Chief of the Bureau of Animal Industry.

Hon. James Wilson,
Secretary of Agriculture.

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SOME COMMON DISINFECTANTS.

INTRODUCTION.

There is much popular misconception as to the value and limitations of the various disinfectants which are sold in this country. For this reason the following very brief description of some of the more common of them has been prepared. Full and complete descriptions of these substances may be found in the very excellent treatises of Rosenau,[a] Rideal,[b] and others.

FORMALDEHYDE.

Formaldehyde—formic aldehyde—is available on the market as paraform (a sort of condensed formaldehyde, which is sold as a white powder or in the form of pastils) and also in aqueous solution generally known under the name of formalin. The solution is supposed to contain 40 per cent of formaldehyde, though in reality the amount of formaldehyde present rarely exceeds 37 to 38 per cent. Formaldehyde may be used for disinfection in either a liquid or gaseous form.

LIQUID FORMALDEHYDE.

Solutions of formaldehyde are best prepared by making a 5 per cent solution of formalin in water. This is applied directly to substances that require disinfection, and in the case of refuse, excreta, and similar substances should be thoroughly mixed with them. A 5 per cent solution of formalin is generally regarded as superior to carbolic acid of the same strength as a general disinfectant.

GASEOUS FORMALDEHYDE.

In disinfecting with formaldehyde gas it is essential that the compartments to be disinfected be tightly closed so that a sufficient concentration of the gas may be held in contact with the infected substances a sufficient length of time. The temperature of the air is an important factor in securing efficient action, the formaldehyde being much more energetic in a warm atmosphere than in a cold. The best authorities state that gaseous formaldehyde disinfection should not be attempted if the temperature of the air is below 50° F. The gas is most conveniently secured by liberating it from the concentrated aqueous 40 per cent solution or from the solid paraform. A number of methods for accomplishing this in practice have been devised, the more important of these being as follows:

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[a] Disinfection and Disinfectants. Philadelphia, 1902.

[b] Disinfection and the Preservation of Food. New York, 1903.

PRODUCTION OF THE GAS FROM FORMALIN.

Heating under pressure.—Portable autoclaves specially designed for the purpose are charged with a sufficient amount of formalin, the quantity depending upon the cubic air space to be disinfected. The autoclave is closed and heat is applied until the required pressure within the autoclave is attained. The gas which has been liberated from the solution by the heat is allowed to flow through an outlet tube into the closed chamber which is to be disinfected. The room is then kept closed for from two to twelve hours; the shorter time if only smooth surfaces are to be acted upon; the longer if penetration into fabrics is desired. Ten ounces of formalin should be used for each 1,000 cubic feet of air space.

Heating without pressure.—This method is similar to that just described. Formalin is placed in a specially designed retort and heated with a lamp. The gas is conducted into the compartment to be disinfected by means of a small tube which passes through the keyhole, or other small aperture. Ten ounces of formalin is required for each 1,000 cubic feet of space. The evolution of gas by this method is less rapid than when generated under pressure and a longer time is required for disinfection. The compartment should remain closed for at least six hours, and for twelve hours if penetration into the interior of fabrics, hay, etc., is required.

Spraying.—In this method the formalin is sprayed upon the surface of objects which require disinfection or upon sheets which are hung up in the compartment containing the infected materials. The gas is liberated by simple evaporation, this liberation being favored by the wide surface which is exposed. The gas is liberated much more slowly by this method than by either of those already described, and the diffusion is also relatively much slower. For these reasons the compartment to be disinfected should not be very large, and should remain closed for at least twenty-four hours. Not less than 10 ounces of formalin should be used for each 1,000 cubic feet of space.

Liberation of the gas by chemical means.—Several methods of liberating formaldehyde from formalin solutions without the use of artificial heat have been proposed in recent years. The most important of these is known as the "permanganate method." Formalin is poured upon crystallized or powdered potassium permanganate. A violent chemical reaction takes place immediately, heat is generated, and a rapid liberation of formaldehyde gas takes place. As will be understood, the heat is caused by the reaction between the formaldehyde in solution and the permanganate, a large portion of the formaldehyde being consumed by the reaction. The amount of gas evolved depends in great measure upon the relative weights of permanganate and formalin employed. Experiments have shown that when the formalin and permanganate are mixed in the proportion of 6 parts of formalin to 5 parts of chemically pure permanganate, by weight, 50 per cent of the formaldehyde employed is liberated in the form of gas. If 10 ounces of formalin are required for disinfection of 1,000 cubic feet of space by the first three methods described, twice that amount is necessary when the permanganate method is employed, as half of the formaldehyde is destroyed by the reaction. For disinfecting 1,000 cubic feet, therefore, use 20 ounces of formalin and $16\frac{2}{3}$ ounces of permanganate. The needle-shaped crystals of potassium permanganate should be employed. Place the required amount of permanganate in a wide-bottomed vessel (an ordinary dish pan is excellent) and pour the formalin on quickly, then close the compartment for from six to twelve hours, depending upon the character of the materials to be disinfected.

PRODUCTION OF THE GAS FROM PARAFORM AND FROM WOOD ALCOHOL.

Heating paraform.—Lamps provided with a pan for holding the paraform are obtainable on the market. The paraform is placed in the pan and heat applied by means of an alcohol lamp. The evolution of gas in this manner is slow. Two ounces of paraform is required for the disinfection of 1,000 cubic feet of space, and the compartment should remain closed for at least twelve hours. This method is best suited to the disinfection of small spaces.

Generation of formaldehyde from wood alcohol.—Formaldehyde is readily produced by the oxidation of wood alcohol (methyl alcohol). This fact has been taken advantage of for use in practical disinfection. Lamps have been designed by means of which the vapor of wood alcohol is passed over hot, finely divided platinum. This causes the oxidation of the alcohol to formaldehyde, which is given off in the room to be disinfected. There is somewhat more danger from fire when this method is employed than in those previously described. Not less than 25 ounces of wood alcohol should be employed for disinfecting 1,000 cubic feet of space.

ADVANTAGES AND DISADVANTAGES OF FORMALDEHYDE.

The advantages may be summarized as follows:

(1) It is one of the most powerful germicides known.

(2) Its action is not interfered with by albuminous substances.

(3) It is not poisonous and may therefore be used for disinfecting hay and grain without destroying these for food purposes.

(4) It is not injurious to delicate fabrics, paint, or metals. (Formalin solutions will attack iron, but not other metals.)

The disadvantages are, briefly, as below:

(1) The gas has a strong tendency to condense in cold weather and is not reliable as a disinfectant when the air temperature is below 50° F.

(2) It is necessary to seal tightly all compartments which are to be disinfected with the gas in order that penetration may be secured and that the required concentration may be maintained for a sufficient length of time.

CARBOLIC ACID (PHENOL).

Pure carbolic acid is solid at ordinary temperatures and crystallizes in long white needles. It may be purchased in this form or as liquefied carbolic acid (Phenol liquefactum, U. S. P.). The latter form is prepared by adding 1 part of water to 9 parts of the crystals and is employed by pharmacists on account of convenience in dispensing. Carbolic acid must not be confused with "crude carbolic acid" and "liquid carbolic acid," which are described below.

For disinfecting purposes carbolic acid is generally used in watery solution, though powders containing it are sold. A 5 per cent solution of crystallized carbolic acid in water is recommended for general use, for, although weaker solutions have been found efficient for destroying many nonspore-bearing bacteria, the conditions found in practice vary widely and in some cases hinder the action of the disinfectant. As carbolic acid dissolves slowly, the 5 per cent solution should be prepared with warm water, using care to see that all is dissolved before use. For disinfecting large surfaces a spray may be used and the disinfectant should be applied liberally. Garments or implements to be disinfected should remain in the 5 per cent solution for at least one hour.

ADVANTAGES AND DISADVANTAGES OF CARBOLIC ACID.

The advantages are:

(1) It is reasonably effective for destroying nonspore-bearing bacteria.

(2) Its action is only slightly interfered with by albuminous substances.

(3) It does not destroy metals or fabrics in a 5 per cent solution.

(4) It is readily available at all pharmacies.

The following disadvantages may be mentioned:

(1) It can not be depended upon to destroy the spores of such bacteria as anthrax and malignant edema.

(2) It is expensive (the pure phenol costs approximately 75 cents per pound).

CRUDE CARBOLIC ACID.

Probably no substance is so widely used in this country as a household and farm disinfectant as crude carbolic acid, and at the same time there is probably no disinfectant that is so uncertain in its effect if used without a proper understanding of its nature. The commercial crude carbolic acid is one of the products of coal-tar distillation, and consists essentially of a mixture of coal-tar oils and so-called " cresylic acid " with little or no phenol. The oils are practically inert as disinfectants, but the cresylic acid, which is a mixture of cresols and similar homologues of carbolic acid, has very marked disinfecting power.

As crude carbolic acid depends almost exclusively upon the cresylic acid which it contains for its disinfecting power, it should not be employed unless the cresylic acid content is definitely known. Even then it must be regarded as of doubtful efficiency if the percentage of hydrocarbon oils is relatively very large, for the oil will prevent to a great extent the solution of the cresylic acid in water when this is mixed with the crude carbolic acid for use as a disinfectant. As is stated in the paragraph dealing with cresol, the cresylic acid is used in 2 per cent solution in water as a disinfectant. When crude carbolic acid is employed, the amount of " acid " which it contains should be known and the disinfecting solution should be made of such strength that it will contain 2 per cent of cresylic acid. This disinfecting solution or mixture is best applied by means of a spray pump, and while spraying the mixture should be well agitated in order that the oils containing undissolved cresols may be evenly distributed over the surface to be disinfected.

There are found on the market products which are sold as " liquid carbolic acid," " straw-colored carbolic acid," etc.; these, as a rule, contain from 90 to 98 per cent of cresylic acid and very little coal-tar oil. They are considered in the next section dealing with cresols.

CRESOL.

Cresol (tricresol, straw-colored carbolic acid, liquid carbolic acid) is derived from coal tar and is found in the trade in varying degrees of purity. The cresol of the United States Pharmacopœia is a colorless liquid, having a strong odor resembling that of carbolic acid. It consists of a mixture of three closely related bodies, all of which are superior to carbolic acid as disinfectants. The other grades of cresols usually contain a small percentage of impurities, and are sold as "liquid carbolic acid, 95 per cent," "straw-colored carbolic acid," etc. These usually contain from 90 to 98 per cent of cresol, and may be purchased under a guaranty to contain certain definite amounts of cresylic acid. Grades containing less than 90 per cent of cresylic acid are not so desirable as those of a higher degree of purity, as the coal-tar oils which are usually found in such products interfere with the solution of the cresols in water, as already stated.

The commercial cresols guaranteed to contain more than 90 per cent of cresylic acid are relatively cheap and well suited to the disinfection of cars, barns, and yards. For general disinfection a 1½ to 2 per cent solution of cresol in water should be used, allowance being made for the impurities when the cheaper grades are employed. Cresol is not easily soluble in water; therefore, in preparing solutions warm water should be used and care taken to see that all is dissolved before applying the solution. A 2 per cent solution of cresol is regarded as being a more efficient disinfectant than a 5 per cent solution of carbolic acid and should be applied in the same way.

ADVANTAGES AND DISADVANTAGES OF CRESOL.

Briefly, the advantages are:

(1) A 2 per cent solution of cresol is as efficient as a 5 per cent solution of carbolic acid.

(2) It is not interfered with by albuminous substances.

(3) It is cheaper than carbolic acid.

(4) It does not destroy metals or fabrics in a 2 per cent solution.

(5) It is more effective than carbolic acid for destroying spores of bacteria, such as anthrax.

The main drawback to the use of cresol is that it is not readily soluble in water, hence may be used in too weak solution unless great care is taken in the preparation of the solution.

COMPOUND SOLUTION OF CRESOL.

This preparation, known as liquor cresolis compositus, United States Pharmacopœia, is recognized as official by the last edition of the United States Pharmacopœia, and is a mixture of equal parts of cresol (U. S. P.) with a linseed-oil-potash soap. The mixture is a thick, dark, amber-colored fluid which mixes readily with water in all proportions to form a clear soapy solution. A very efficient disinfectant may be made from the commercial cresols or liquid carbolic acids of known strength by mixing these with the soap described in the United States Pharmacopœia under the heading "Liquor cresolis compositus." When other than United States Pharmacopœia cresol is used a sufficient excess must be added to insure 50 per cent of actual cresylic acid in the mixture. Compound solution of cresol is recommended for use as a general disinfectant in a 3 to 4 per cent solution in water. In this strength it will accomplish the same results as a 1½ to 2 per cent solution of cresol and may be applied in the same manner as a 5 per cent solution of carbolic acid.

It may be said in favor of the compound solution of cresol that it possesses all the advantages of cresol, and in addition is far more readily soluble. It is, however, somewhat more expensive than cresol, owing to a stronger solution being required; this is in great measure compensated for by its ready solubility.

CHLORINATED LIME (CHLORID OF LIME).

This substance is prepared by exposing slaked lime to the action of chlorin gas. It is a white powder which gives off a disagreeable odor of chlorin, and decomposes rapidly upon exposure to air. It can not be depended upon unless kept in hermetically sealed containers. It is prepared for use in the general disinfection of cars, pens, or refuse by mixing 6 ounces with a gallon of water. This is applied liberally, and infectious excreta must be mixed thoroughly with the solution to insure disinfection. Chlorinated lime is a powerful deodorant and is valuable for use in foul-smelling cesspools and similar places.

As a disinfectant, chlorinated lime possesses no advantages over formaldehyde, carbolic acid, cresol, etc. It has, moreover, certain disadvantages, chief among which are uncertainty of strength and destructiveness to metals and fabrics.

BICHLORID OF MERCURY.

This is a white crystalline substance which is also known as mercuric chlorid and corrosive sublimate. It is usually prepared for use in the form of tablets with ammonium chlorid, which facilitates the solution of the bichlorid in water. The bichlorid is used in solution in water in a strength of 1 to 1,000, though solutions 1 to 500 may be employed with correspondingly quicker action on nonspore-bearing bacteria and much more effective action on the spores of bacteria. Bichlorid of mercury is a violent poison, and has the property of combining with albuminoids to form inert compounds. These facts necessarily limit its usefulness as a general disinfectant. It should never be used to disinfect excreta, or substances containing blood or serous fluids. Bichlorid solutions should not be kept in lead or tin vessels, or poured through lead pipes, as the mercury combines with these metals and injures them, besides affecting the germicidal efficiency of the solution itself.

The chief advantage in the use of bichlorid of mercury lies in its great germicidal power when employed under proper conditions. The disadvantages are its poisonous nature, its tendency to attack certain metals, and the interference by albuminoids and other organic substances.

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Issued January 23, 1909.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 346.

THE COMPUTATION OF RATIONS FOR FARM ANIMALS BY THE USE OF ENERGY VALUES.

BY

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Animal Industry,
Washington, D. C., November 18, 1908.

Sir: I have the honor to transmit herewith, and to recommend for publication as a Farmers' Bulletin, the manuscript of an article on "The Computation of Rations for Farm Animals by the Use of Energy Values," by Dr. Henry Prentiss Armsby. This paper, aside from dealing with the subject in a general way, makes available to the farmer and feeder some of the results of the investigations carried on under Doctor Armsby's direction at the Institute of Animal Nutrition of The Pennsylvania State College in cooperation with this Bureau.

Very respectfully,

A. D. Melvin,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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THE COMPUTATION OF RATIONS FOR FARM ANIMALS BY THE USE OF ENERGY VALUES.

GENERAL PRINCIPLES.

COMPONENTS OF THE ANIMAL BODY.

The Machinery of the Body.

The essential working parts of the body contain a great variety of substances, but these may, for our present purpose, be grouped under three heads—water, ash, and protein. The bones, constituting the framework of the body; the ligaments, muscles and tendons which bind together and move the bones; the skin and hair, or wool, which cover and protect the body; the internal organs of circulation, respiration, digestion, excretion, and reproduction; the brain and nerves—in short, the whole mechanism of the body—can be regarded as being composed substantially of these three classes of substances.

Water.—Rarely less than half and sometimes as much as three-fourths of the weight of the live animal consists of water. The proportion of water is greatest in young and lean animals and decreases as they become more mature or fatter.

Ash.—The ash or mineral matter is the portion left after complete burning. Its presence is most familiar in the bones, but it is found in all parts of the body and is just as essential as water or protein. It amounts to from 2 to 5 per cent of the weight of the body.

Protein.—Protein is the name given to a highly important group of substances, of which the white of egg, washed lean meat, the casein of milk, the gluten of wheat flour, etc., are familiar examples. They are composed of the chemical elements carbon, hydrogen, oxygen, nitrogen, and sulphur. They are what are commonly called "organic" substances, which simply means that they may be burned completely in air or oxygen. They differ from the other groups of substances found in the animal body in containing sulphur and especially nitrogen, the latter element constituting from 15 to 18 or 19 per cent of their weight.

Protein is the basis of the living tissues of the body—the so-called protoplasm—and is the substance through which life especially manifests itself. In the body it is always associated with water and ash.

The Reserve Material of the Body.

Fat.—Besides its working parts, the body contains a store of reserve material in the form of fat. While the fat deposits in the body are of use mechanically as cushions between the various organs and as a protecting layer under the skin, nevertheless fat represents essentially a storage of material derived from food consumed in excess of the body's immediate needs. When the food is insufficient or entirely lacking, this store of surplus material is drawn upon, and the animal gradually becomes lean. The percentage of fat in the bodies of agricultural animals may vary greatly, but seldom falls below 6 or rises above 30 per cent.

Glycogen.—Besides fat there are stored up in the muscles, liver, and other organs of a healthy animal rather small amounts of a substance called "glycogen," belonging to the group of carbohydrates described in the next section. Neither fat nor glycogen contains the elements nitrogen or sulphur, but each is composed entirely of carbon, hydrogen, and oxygen.

Composition of the Entire Body.

The average results of analyses shown in the following table indicate the composition of the bodies of different animals in different conditions:

Percentage composition of live animals.

	Ox.			Fat calf.	Sheep.					Swine.	
	Well fed.	Half fat.	Fat.		Lean.	Well fed.	Half fat.	Fat.	Very fat.	Well fed.	Fat.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Water	54.3	50.2	43.6	60.1	56.6	53.7	50.7	44.8	39.0	53.9	42.0
Ash	4.8	4.4	3.9	4.5	3.4	3.3	3.2	2.9	2.8	2.7	1.8
Fat	7.1	14.9	26.8	13.1	8.6	13.2	18.3	28.1	37.2	22.5	40.2
Protein	15.8	15.5	13.7	15.3	15.4	14.8	13.8	12.2	11.0	13.9	11.0
Contents of stomach and intestines	18.0	15.0	12.0	7.0	16.0	15.0	14.0	12.0	10.0	7.0	5.0
Total	100 0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

COMPONENTS OF FEEDING STUFFS.

Like the animal body, the vegetable feeding stuffs which nourish it contain a great variety of substances, but these, too, like those of the animal, may be classified into a few groups. Not only so, but these main groups are the same as those found in the animal, viz, water, ash, protein, fats, and carbohydrates. The proportions of these ingredients in the animal body and in vegetable substances, however, are widely different.

Protein and Fat.

Protein is the predominant ingredient, aside from water, in the animal body, while the latter stores up its reserve material in the form of fat with but little carbohydrates (glycogen). Protein is also contained in all plants and, as in the animal, forms the basis of the living tissues, but the predominant ingredients as regards quantity are the carbohydrates. In the form of cellulose, or "crude fiber," they form the cell-walls of the plant, while as starch and sugar they are stored up in large amounts in the cells of seeds and roots as reserve material. A few plants, like flax and cotton, store up oil instead of starch and are likewise rich in protein, but as a rule the common feeding stuffs contain relatively small amounts of protein and fat and are rich in carbohydrates.

The protein and fats of plants are not widely different from those of animals and call for no special description here.

Carbohydrates.

The carbohydrates, as starch, sugar, etc., constitute a distinct group, represented in the animal chiefly by the small amounts of glycogen mentioned on page 6 and by the sugar of the milk. They are composed of the chemical elements carbon, hydrogen, and oxygen, the two latter being present in exactly the same relative amounts as in water. Like the fats, they contain no nitrogen or sulphur, but they differ from the fats in containing less carbon and more oxygen.

The carbohydrates of feeding stuffs may be divided into two classes. The first of these includes those substances which are found in the cell walls and constitute the framework of the plant. This class includes cellulose and a great variety of other substances, most of which are rather difficult to dissolve. The "crude fiber" obtained in the analysis of feeding stuffs represents this class of carbohydrates.

The second class of carbohydrates consists of the reserve material stored up in the cells and includes starch, the various kinds of sugar, and other less familiar substances. Some of these carbohydrates, like the sugars, dissolve in water and all may be converted into soluble forms rather easily. In analyses of feeding stuffs they are contained in the "nitrogen-free extract" which, however, also includes a variety of other substances of ill-defined nature.

Average Composition of Feeding Stuffs.

The following table shows the average composition of a considerable number of American feeding stuffs. In this table the common practice has been followed of dividing the group of carbohydrates into two portions. The "crude fiber" or "woody fiber" is stated separately, partly because it is of somewhat inferior nutritive value and partly because it gives some indication of the bulkiness and woodiness of the feeding stuff. The column headed "nitrogen-free extract" includes all the carbohydrates except the crude fiber—that is, the sugar, starch, etc.

Average composition of feeding stuffs.

[From Farmers' Bulletin No. 22. revised edition.]

Feeding stuff.	Water.	Ash.	Crude protein.[a]	Carbohydrates.		Fat (ether extract).
				Crude fiber.	Nitrogen-free extract.	
Green fodder and silage:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Alfalfa	71.8	2.7	4.8	7.4	12.3	1.0
Clover—crimson	80.9	1.7	3.1	5.2	8.4	.7
Clover—red	70.8	2.1	4.4	8.1	13.5	1.1
Corn fodder	79.3	1.2	1.8	5.0	12.2	.5
Corn silage	74.4	1.5	2.2	5.8	15.0	1.1
Hungarian grass	71.1	1.7	3.1	9.2	14.2	.7
Rape	85.7	2.0	2.4	2.2	7.1	.6
Rye fodder	76.6	1.8	2.6	11.6	6.8	.6
Timothy	61.6	2.1	3.1	11.8	20.2	1.2
Hay and dry coarse fodders:						
Alfalfa hay	8.4	7.4	14.3	25.0	42.7	2.2
Clover hay—red	15.3	6.2	12.3	24.8	38.1	3.3
Corn forage, field cured	42.2	2.7	4.5	14.3	34.7	1.6
Corn stover, field cured	40.5	3.4	3.8	19.7	31.5	1.1
Cowpea hay	10.7	7.5	16.6	20.1	42.2	2.9
Hungarian hay	7.7	6.0	7.5	27.7	49.0	2.1
Oat hay	16.0	6.1	7.4	27.2	40.6	2.7
Soy bean hay	11.3	7.2	15.4	22.3	28.6	5.2
Timothy hay	13.2	4.4	5.9	29.0	45.0	2.5
Straws:						
Oat straw	9.2	5.1	4.0	37.0	42.4	2.3
Rye straw	7.1	3.2	3.0	38.9	46.6	1.2
Wheat straw	9.6	4.2	3.4	38.1	43.4	1.3
Roots and tubers:						
Carrots	88.6	1.0	1.1	1.3	7.6	.4
Mangel-wurzels	91.2	1.0	1.4	.8	5.4	.2
Potatoes	78.9	1.0	2.1	.6	17.3	.1
Rutabagas	88.6	1.2	1.2	1.3	7.5	.2
Turnips	90.6	.8	1.3	1.2	5.9	.2
Grains:						
Barley	10.9	2.4	12.4	2.7	69.8	1.8
Corn	10.9	1.5	10.5	2.1	69.6	5.4
Corn-and-cob meal	15.1	1.5	8.5	6.6	64.8	3.5
Oats	11.0	3.0	11.8	9.5	59.7	5.0
Pea meal	10.5	2.6	20.2	14.4	51.1	1.2
Rye	11.6	1.9	10.6	1.7	72.5	1.7
Wheat	10.5	1.8	11.9	1.8	71.9	2.1
By-products:						
Brewers' grains—dried	8.0	3.4	24.1	13.0	44.8	6.7
Brewers' grains—wet	75.7	1.0	5.4	3.8	12.5	1.6
Buckwheat middlings	11.8	4.8	28.0	6.3	41.9	7.2
Cotton-seed meal	8.2	7.2	42.3	5.6	23.6	13.1
Distillers' grains—dried—						
Principally corn	7.0	2.0	29 2	11.0	39.4	11.4
Principally rye	6.8	2.1	17.3	12.3	54.0	7.5
Gluten feed—dry	8.1	1.3	23.2	6.4	54.7	6.3
Gluten meal—Buffalo	8.2	.9	24.5	6.1	47.8	12.5
Gluten meal—Chicago	8.1	1.0	28.3	1.1	50.8	10.7
Linseed meal—old process	9.2	5.7	32.9	8.9	35.4	7.9
Linseed meal—new process	9.9	5.6	35.9	8.8	36.8	3.0
Malt sprouts	10.2	5.7	23.2	10.7	48.5	1.7
Rye bran	11.8	3.5	14.7	3.3	63.9	2.8
Sugar-beet pulp—fresh	89.9	.4	1.0	2.2	6.3	.2
Sugar-beet pulp—dried	6.4	3.3	10.8	19.8	58.4	1.3
Wheat bran	11.9	5.8	15.4	9.0	53.9	4.0
Wheat middlings	11.8	4.8	28.0	6.3	41.9	7.2

[a] Total N × 6.25.

THE ANIMAL BODY AS A MACHINE.

Mechanically the body of an animal is a very wonderful machine, but what is of peculiar interest in this connection is that the body is what the engineer calls a prime motor—that is, like the steam or gasoline engine, it moves itself and may supply power to move other machines. In fact, there is in some respects a very close likeness between the animal body and what are known as internal-combustion motors, i. e., those engines in which power is developed by burning liquid or gaseous fuel (gasoline, alcohol, producer gas, etc.) in the cylinder of the engine itself. Such an engine requires two things for its operation: (1) Sufficient repair material to keep its working parts in running order, and (2) a supply of fuel in proportion to the work to be done. Just these same two things are what the animal requires—repair material and fuel.

In one respect, however, the animal body differs from the artificial machine—it can not be stopped and started again at will. As long as the animal lives the vital machinery is in operation, although less actively at some times than at others. The animal might be compared to an automobile whose engine must be kept running at a low speed in order to have the power available when needed. Consequently, the animal requires to be supplied with repair material and with fuel as long as it lives and not merely when it is in active use.

That the feed of the animal is its source of both repair material and fuel is sufficiently obvious. We do not need a physiologist to tell us that when an animal is deprived of food its tissues waste away while its fat is burned up in the effort to keep the bodily machinery in motion. We may proceed at once, therefore, to consider the feed in these two relations.

The Demand for Repair Material.

The repair material for any machine must be of the same kind of which the machine is made. We have just seen that the machinery of the body is composed of protein, ash, and water. These, then, are the materials which must be supplied to keep it in repair.

Water, of course, is or should be abundantly supplied in the drink and scarcely need be considered in a discussion of rations.

Ash.—The ash supply has received less attention in the past than its importance deserves. In the ordinary operation of the bodily machinery its ash ingredients are being continually excreted and the food must supply ash sufficient in amount and of the right kinds to make good the loss, while the growing animal needs an additional supply for building up its new tissues. Fortunately, normally constituted rations appear to be rarely deficient in ash. Usually it is only when large amounts of certain by-product feeds are used or when there is a misrelation between grain and coarse fodder that special attention needs to be given to the ash supply.

Protein.—The protein supply, on the other hand, calls for careful consideration. Protein is the characteristic ingredient of the animal mechanism, and is broken down and destroyed in its operation at a fairly regular rate. Moreover, since the bodily machinery is running all the time, whether any external work is done or not, this loss is continually going on.

The body differs from a machine in being self-repairing, but it can not manufacture protein for repair purposes out of the carbohydrates and fats of its feed any more than it is possible to make repairs for an automobile out of the gasoline which supplies the power. For its protein the body is absolutely dependent on the protein of the feed. This protein is needed for two purposes.

First. It is required for repair purposes in the strict sense; i. e., for making good the wear and tear of the bodily machinery. The amount needed for this purpose is comparatively small, and is no greater under normal conditions when the animal is doing work than when it is not. Like a good engine, the body makes relatively small demands for repair material and requires chiefly fuel.

Second. Protein as well as ash is needed in the growing, pregnant, or milking animal to furnish the material for enlarging the working machinery of the body of the animal itself or of its young. The amount of protein required for this purpose is just so much in addition to that needed for repair purposes simply, and hence the feed of these animals must contain a more liberal supply of this ingredient. This is important physiologically to secure proper nutrition of the young and economically because the growth or milk produced is the principal object of the feeder.

Feed as a Source of Repair Material.

For the reasons stated on page 9, the ash has generally been omitted from consideration in discussing the feed as a source of repair material.

The value of a feeding stuff as a source of protein to the animal body evidently depends in the first place on the amount of protein which it contains. Cotton-seed meal, carrying some 43 per cent of protein, is evidently, other things being equal, a better source of protein than Indian corn, carrying about 10 per cent.

In the second place, however, the protein of the feeding stuff must be capable of being digested by the animal. Of two feeding stuffs containing equal amounts of protein, that one is the more valuable as a source of supply in which the larger proportion of the protein is digestible. The second column of the table on page 15 shows the average percentage of digestible protein contained in a number of the more common feeding stuffs. These figures are the average results of a considerable number of analyses of the feeding stuffs and a smaller number of determinations of their digestibility. Individual samples may vary more or less, and sometimes considerably, from the average.

A third question is at once suggested, viz, whether the digestible protein from different feeding stuffs is equally valuable to the animal. It is unlikely that this is *exactly* the case, but whether these probable differences are of much practical significance, especially in rations containing a number of feeding stuffs, seems doubtful. At any rate, the only course open at present is to assume them to be of substantially equal value.

The Demand for Fuel Material.

Since the animal machinery is running continually, it requires a continual supply of fuel material, the amount which is necessary depending upon the amount of work done. This fuel material consists chiefly of the carbohydrates and fats of the food, although if more protein be fed than is required for repair and construction purposes it, too, may be used as fuel, while the worn-out portions of the protein tissues are also utilized—that is, the bodily engine can burn up its own waste products as fuel. The unnecessary use of protein as fuel material, however, is wasteful, because protein is ordinarily more expensive to buy or to produce on the farm than are carbohydrates and fats.

If the fuel materials supplied in the food are just adequate to the work to be done, they are virtually burned up as a source of power. If more are supplied than are immediately needed, the body is able to store away the surplus for future use, much as we may fill up the gasoline tank of an engine. To a small extent the body stores up carbohydrates (in the form of glycogen), but most of its surplus fuel it converts into fat. The fat of the body, therefore, is its reserve of fuel. In fattening, the body is accumulating a surplus against future needs which man diverts to his own use as food. If the feed becomes insufficient, this store is drawn upon and the animal gradually becomes lean. Similarly, in growth and in milk production, the animal sets aside a part of the supply of both repair and fuel material in its food for its own growth or for the use of its young, and man appropriates the resulting meat or milk as repair and fuel material for his own body.

Feed as a Source of Fuel Material.

We can run an engine with various kinds of fuel. For the steam engine we may use coal or wood or petroleum; for the internal-combustion motor, gas, alcohol, or gasoline may be employed. Similarly, we supply the animal body with a great variety of feeding stuffs from which it has to extract its supply of fuel, and even the materials which it actually burns up are of various sorts.

These fuel materials are not all of equal value. A pound of good anthracite coal, for example, is, other things being equal, about 14 per cent more valuable as fuel than the same weight of alcohol, while a pound of fat in the food has over twice the fuel value of a pound of starch. Evidently, it will greatly simplify comparisons of different feeding stuffs and rations as sources of fuel material to have some simple method by which we can learn not only the amount of fuel material which the feed contains, but also the quality of that fuel. Such a basis of comparison is afforded by a study of the energy values.

Measurement of Energy.

Anything which has the capacity to do work is said to possess energy. Hence we say that the fuel of the engine and the feed of the animal possess energy, since they enable the engine or the body to do work. They hold this energy stored up in the " latent " or " potential " form of chemical energy. When they are burned in the engine or the body, this chemical energy is set free, part of it being converted into work and the rest escaping as heat.

Plainly, then, the value of a fuel, or of a feeding stuff so far as it serves as fuel, depends, in the first place, on how much chemical energy it contains. This can be measured without difficulty by converting it all into heat, by burning the substance, and measuring the heat produced. Various units have been employed in measuring heat, but the one used in this bulletin is the therm.

A therm[a] is the quantity of heat required to raise the temperature of 1,000 kilograms (2,204.6 pounds) of water 1° C. A pound of good anthracite coal would produce heat enough to raise the temperature of about 3,583 kilograms of water 1° C. Consequently, the chemical energy contained in the coal is 3.583 therms per pound. In precisely the same way the amount of chemical energy contained in many feeding stuffs has been measured. The following are the results of a few such determinations:

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[a] In the nutrition investigations and studies of foods and feeding stuffs made by this Department and by the State agricultural experiment stations, the results, so far as energy or fuel value is concerned, have been expressed in calories. There is consequently a large mass of available data so expressed. The calorie is the amount of heat required to raise 1 kilogram of water 1° C. (approximately 1 pound of water 4° F.). The small size of the unit has made it necessary to use inconveniently large numbers to express the fuel values of foods and feeding stuffs, a difficulty which is obviated by the use of the therm. As the latter unit is equivalent to 1,000 calories, available data, such, for example, as those in Farmers' Bulletin No. 22, can be readily given expression in the new unit. The use of the word therm, with the abbreviation *t.*, has also been proposed as the equivalent of the small (or gram) calorie, but it has not come into general use.

Chemical energy in 100 pounds.[a]

	Therms.
Timothy hay	175.1
Clover hay	173.2
Oat straw	171.0
Wheat straw	171.4
Corn meal	170.9
Oats	180.6
Wheat bran	175.5
Linseed meal	196.7

Utilization of Energy.

But the value of a fuel depends also upon how much of the chemical energy which it contains can be used. Hard coal contains plenty of energy, but it would not be of much use to run a gasoline engine. Wheat straw contains fully as much chemical energy as corn meal, but much of that energy can not be utilized by the animal machine.

Two causes combine to affect the utilization of the chemical energy contained in feeding stuffs.

First, more or less of the feed escapes from the body unburned. If a coal is of such quality that portions of it drop through the grate unconsumed, and if smoke and combustible gases are carried off through the stack, it is evident that a ton of it will supply far less heat to the boiler than it would if the combustion were perfect. The case of the feeding stuff is similar. Much of even the best feeding stuffs escapes digestion and is excreted in the dung, carrying with it a corresponding quantity of the chemical energy of the feed. More or less incompletely burned material is also contained in the urine, while ruminants, and to a certain extent horses, also give off combustible gases, arising from fermentations in the digestive tract. Thus about 22 per cent of the chemical energy of corn meal and fully 55 per cent of that of average hay has been found to escape in these ways.

Second, as already pointed out, the animal body has to extract its real fuel material from its feed, separating it from the relatively large proportion of useless material which it excretes. To effect this separation requires work and consumes energy, and this energy, of course, is not available for other purposes. The case is somewhat as if the gasoline engine had to distill its own gasoline and separate it from impurities. Moreover, when the animal eats more feed than is required simply to furnish energy to run its machinery, and hence is able to produce meat or milk, the process of converting the food into suitable forms to store up in the body seems to require a further expenditure of energy.

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[a] With 15 per cent moisture.

It is not, then, the total chemical energy contained in a feeding stuff which measures its value as fuel material to the body, but what remains after deducting the losses in the unburned materials of the excreta and the energy expended in extracting the real fuel materials from the feed and transforming them into substances which the body can use or store up. For example, while 100 pounds of corn meal contain, as stated, about 170.9 therms of chemical energy, only about 88.8 therms remain, after all these deductions have been made, to represent the actual value of the corn meal as a source of energy to the organism.

Energy Values of Feeding Stuffs.

While it is a comparatively simple matter to ascertain the total amount of chemical energy contained in a feeding stuff, the determination of the proportion of this energy which the body can actually utilize requires the use of complicated and costly apparatus (respiration apparatus or respiration calorimeter) and the expenditure of much time and labor. While much has been accomplished along this line, vastly more still remains to be done before we can claim to have even a fairly complete knowledge of the energy values of feeding stuffs. At the same time, enough has already been accomplished, chiefly through the investigations of G. Kühn and of Kellner at the Möckern Experiment Station in Germany, since 1882, and in part also by experiments carried on, in coöperation with this Department, by the Institute of Animal Nutrition of The Pennsylvania State College, to demonstrate that the method still generally current of comparing feeding stuffs on the basis of the digestible matter which they contain is seriously erroneous and to furnish the beginnings of a reform.

The last column of the following table contains the energy values of the feeding stuffs, whose composition was given on page 8, computed on the basis of Kellner's investigations. They are what Kellner calls *production values*—i. e., they show primarily the value of these different feeding stuffs for the production of gain in mature fattening cattle. Even for this purpose many of them are confessedly approximate estimates, and still less can they be regarded as strictly accurate for other kinds of animals and other purposes of feeding. Nevertheless, there seems to be reason for believing that they also represent fairly well the relative values of feeding stuffs for sheep at least, and probably for horses, and for growth and milk production as well as for fattening. At any rate, there can be little doubt that they are decidedly more accurate than the figures which have been commonly used, and we are quite justified in using them tentatively and subject to correction by the results of later experiments.

As regards swine, the matter is far less certain, and it may perhaps be questioned whether the values given in the table are any more satisfactory for this animal than the older ones.

Dry matter, digestible protein, and energy values per 100 pounds.

Feeding stuff.	Total dry matter.	Digestible protein.	Energy value.
Green fodder and silage:	*Pounds.*	*Pounds.*	*Therms.*
Alfalfa	28.2	2.50	12.45
Clover—crimson	19.1	2.19	11.30
Clover—red	29.2	2.21	16.17
Corn fodder—green	20.7	.41	12.44
Corn silage	25.6	1.21	16.56
Hungarian grass	28.9	1.33	14.76
Rape	14.3	2.16	11.43
Rye	23.4	1.44	11.63
Timothy	38.4	1.04	19.08
Hay and dry coarse fodders:			
Alfalfa hay	91.6	6.93	34.41
Clover hay—red	84.7	5.41	34.74
Corn forage, field cured	57.8	2.13	30.53
Corn stover	59.5	1.80	26.53
Cowpea hay	89.3	8.57	42.76
Hungarian hay	92.3	3.00	44.03
Oat hay	84.0	2.59	36.97
Soy bean hay	88.7	7.68	38.65
Timothy hay	86.8	2.05	33.56
Straws:			
Oat straw	90.8	1.09	21.21
Rye straw	92.9	.63	20.87
Wheat straw	90.4	.37	16.56
Roots and tubers:			
Carrots	11.4	.37	7.82
Mangel-wurzels	9.1	.14	4.62
Potatoes	21.1	.45	18.05
Rutabagas	11.4	.88	8.00
Turnips	9.4	.22	5.74
Grains:			
Barley	89.1	8.37	80.75
Corn	89.1	6.79	88.84
Corn-and-cob meal	84.9	4.53	72.05
Oats	89.0	8.36	66.27
Pea meal	89.5	16.77	71.75
Rye	88.4	8.12	81.72
Wheat	89.5	8.90	82.63
By-products:			
Brewers' grains—dried	92.0	19.04	60.01
Brewers' grains—wet	24.3	3.81	14.82
Buckwheat middlings	88.2	22.34	75.92
Cotton-seed meal	91.8	35.15	84.20
Distillers' grains—dried—			
Principally corn	93.0	21.93	79.23
Principally rye	93.2	10.38	60.93
Gluten feed—dry	91.9	19.95	79.32
Gluten meal—Buffalo	91.8	21.56	88.80
Gluten meal—Chicago	90.5	33.09	78.49
Linseed meal—old process	90.8	27.54	78.92
Linseed meal—new process	90.1	29.26	74.67
Malt sprouts	89.8	12.36	46.33
Rye bran	88.2	11.35	56.65
Sugar-beet pulp—fresh	10.1	.63	7.77
Sugar-beet pulp—dried	93.6	6.80	60.10
Wheat bran	88.1	10.21	48.23
Wheat middlings	84.0	12.79	77.65

FEED REQUIREMENTS.

Assuming that the foregoing table represents with a fair degree of accuracy the amount of repair material (protein), on the one hand, and of energy, on the other, which the various feeding stuffs can supply, we still need to know how much of each is required by the bodies of animals of different kinds and kept for different purposes; in other words, we need some formulation of the feed requirements of farm animals.

Requirements for Maintenance.

Since the animal machine can not be stopped when it is not in active use, it requires, as was pointed out on page 9, and as is a familiar fact of experience, a continual supply of food. This amount of food, which is required simply to support the animal, is commonly designated as the "maintenance requirement"—i. e., it is the amount required simply to maintain the animal when it is doing no work and producing nothing. In other words, it is the least amount on which life can be permanently maintained.

The maintenance requirement is naturally greater for a large than for a small animal. Experiment has shown, however, that this increase is not proportional to the weight of the animal, but approximately to the amount of surface which it exposes, so that the large animal requires less food in proportion to its weight to maintain it than does the small one.

The following tables show the amounts of protein and of energy required per head for the maintenance of cattle, sheep, and horses of different weights. The figures given for sheep include a sufficient allowance for the normal growth of wool. No very satisfactory figures for swine are available. It should be understood that strict accuracy is not claimed for these figures, although they are substantially correct. In particular there seems to be reason to believe that the maintenance requirement of fattening animals increases somewhat more rapidly than these tables indicate.

Maintenance requirements of cattle and horses, per day and head.

Live weight.	Cattle.		Horses.	
	Digestible protein.	Energy value.	Digestible protein.	Energy value.
Pounds.	*Pounds.*	*Therms.*	*Pounds.*	*Therms.*
150	0.15	1.70	0.30	2.00
250	.20	2.40	.40	2.80
500	.30	3.80	.60	4.40
750	.40	4.95	.80	5.80
1,000	.50	6.00	1.00	7.00
1,250	.60	7.00	1.20	8.15
1,500	.65	7.90	1.30	9.20

Maintenance requirements of sheep, per day and head.

Live Weight.	Digestible protein.	Energy value.
Pounds.	*Pounds.*	*Therms.*
20	0.23	0.30
40	.05	.54
60	.07	.71
80	.09	.87
100	.10	1.00
120	.11	1.13
140	.13	1.25

Requirements for Growth.

While young animals gain in weight faster than do older ones, a pound of increase in live weight in the young animal contains much more water and less dry matter than in the case of a more mature animal. Moreover, the dry matter in the case of the young animal contains relatively more protein and less fat, as a rule, than in the older one, and fat contains much more chemical energy than protein, the proportion being 1 to 1.67. The consequence is that a gain of 1 pound in live weight represents the storing up of much less energy in the young than in the mature animal, and therefore requires a smaller supply of energy in the food.

Unfortunately no very extensive determinations of the composition and energy values of the increase of live weight in growing animals have yet been reported. The following estimates by the writer, derived from such data as are available, may serve to give a general idea of the requirements per pound of growth of cattle and sheep at different ages, but they can not lay claim to any high degree of accuracy. The figures refer to normal growth, with no considerable fattening.

Estimated energy value of 1 pound of gain in weight by growing cattle and sheep.

Age.	Energy value.
Months.	*Therms.*
3	1.50
6	1.75
12	2.00
18	2.50
24	2.75
30	3.00

The growing animal also requires a sufficient supply of digestible protein for maintenance and to supply material for new growth. No very systematic study of the latter requirement has yet been made, but from the results of a considerable number of practical feeding trials it is possible to make a fairly satisfactory estimate of the total amounts of digestible protein which should be contained in the rations of cattle and sheep at different ages to insure satisfactory growth. These estimates are contained in the following table. They are expressed in pounds per head and *include the maintenance requirement.* As a matter of convenience, the table also contains the estimated energy values required per head for normal growth, and it thus constitutes a set of approximate feeding standards. In their use the weight rather than the age of the animal should be the controlling factor.

Estimated requirements[a] *per day and head.*

FOR GROWING CATTLE.

Age.	Live weight.	Digestible protein.	Energy value.
Months.	*Pounds.*	*Pounds.*	*Therms.*
3	275	1.10	5.0
6	425	1.30	6.0
12	650	1.65	7.0
18	850	1.70	7.5
24	1,000	1.75	8.0
30	1,100	1.65	8.0

FOR GROWING SHEEP.

6	70	0.30	1.30
9	90	.25	1.40
12	110	.23	1.40
15	130	.23	1.50
18	145	.22	1.60

[a] Including the maintenance requirement.

No satisfactory data for colts are available, while, as noted on page 15, our knowledge of the relative values of feeding stuffs for swine is somewhat deficient.

Requirements for Fattening.

The foregoing data refer to what might be called normal growth, in which the animals are kept in a good thrifty condition, but do not become fat. If any considerable fattening is desirable, somewhat heavier rations must be given in proportion to the amount of gain made, because the increased gain in fattening animals consists to a very large extent of fat, and therefore means the storing up by the animal of more reserve energy. For fairly mature fattening animals—such, for example, as the 2 to 3-year-old steers which are commonly fattened in the corn belt—probably 3.5 therms per pound of gain in live weight is a fair allowance, although more appears to be often used in practice. As yet no corresponding data are available for the fattening of growing animals, as, for example, in the production of the so-called "baby beef." It is not probable, however, that any larger amount of protein is required in such fattening than in feeding simply for normal growth, so that the additional food given for fattening may, from this point of view, consist largely of nonnitrogenous material, i. e., carbohydrates and fats. It is to be noted, however, that an excess of these materials in the ration tends to cause less perfect digestion, and also that a moderate proportion of the more nitrogenous concentrates seems to aid in securing the consumption of heavy rations. Kellner recommends that at least 1 pound of digestible protein be supplied in the ration for each 8 to 10 pounds of carbohydrates and fat.

Requirements for Milk Production.

Of all forms of animal production that of milk is perhaps the most variable and most influenced in its amount by the feed supply. The energy relations of milk production have not been very fully investigated. Tentatively, however, it seems safe to estimate that the production of 1 pound of average milk, containing about 13 per cent of total solids and 4 per cent of fat, will require approximately 0.3 therm of production value in the feed. Naturally this amount would vary with the quality of the milk, milk rich in fat and in total solids requiring more than milk containing more water or a lower percentage of fat.

The matter of the protein requirements for milk production has not been altogether cleared up. It seems to have been pretty well demonstrated that, for a time at least, milk production may be kept up on a supply of protein very slightly exceeding that found in the milk produced (of course, in addition to the maintenance requirement). In the case of average milk, this would call for about 0.032 pound of digestible protein for each pound of milk. It has not been demonstrated, however, that a cow can keep this up indefinitely. Furthermore, for the production of liberal yields of milk more protein seems to be required, or at least to be advantageous. No definite statement can be made at present as to how large an excess is necessary. For the ordinary commercial dairyman, however, it is believed that an allowance of 0.05 pound of digestible protein per pound of milk will prove ample.

Requirements for Work.

Since the horse (or mule) is the usual working animal in the United States, consideration will be limited to this animal.

There is on record a considerable amount of data as to the relation between the work performed by the horse and the amount of energy necessary to be supplied in the feed. Where large numbers of horses are kept and the work is relatively uniform in amount, it is possible to make fairly satisfactory computations from these data, although the method is somewhat complicated. The amount of work required of farm horses, however, is so varied in amount and kind and so difficult of measurement or estimate as regards amount, that it is scarcely practicable to base the calculation of rations upon it. The table on page 15 probably shows with at least a fair degree of accuracy the relative values of different feeding stuffs as sources of energy for work production, while the amount to be fed will ordinarily be based upon the observation of the feeder rather than upon arithmetical calculations. As a sort of general average, however, Kellner recommends the following rations for a 1,000-pound horse, the amounts stated including the maintenance requirement:

Requirements of the working horse.

	Digestible protein.	Energy value.
	Pounds.	*Therms.*
For light work	1.0	9.80
For medium work	1.4	12.40
For heavy work	2.0	16.00

Dry Matter in Rations.

The total volume of feed which an animal requires, although rather variable, has its limits. In computing rations the most convenient indication of the bulk of the feeds is the percentage of dry matter shown in the first column of the table on page 15. In very general terms it may be said that a 1,000-pound ruminant should be given from 20 to 30 pounds of dry matter per day, 25 pounds being perhaps a fair average, while for the horse smaller amounts will be appropriate.

A study of the table shows that concentrated feeding stuffs contain much more protein and energy in proportion to their dry matter than do the forage crops. Evidently, then, in heavy feeding, where the purpose is to give the animal all the feed possible, the ration should consist as largely as practicable of concentrated feeding stuffs, because only in that way can the required amount of food be obtained without unduly increasing the bulk of the ration. On the other hand, in light feeding the coarse fodders may predominate, because they are usually relatively cheaper and can supply the required amount of food in a bulk which the animal can consume.

THE COMPUTATION OF RATIONS.

GENERAL CONSIDERATIONS.

In the foregoing pages we have considered the requirements of the animal machine for repair material (protein), and for fuel material (energy), and have also studied the food as a source of these two. If we knew exactly the requirements of the animal in any given case, and if we knew exactly what amounts of protein and energy the feeding stuffs at our disposal could furnish, the computation of a ration would be almost purely a matter of arithmetic. We would simply have to devise a mixture of the feeding stuffs which would yield the requisite amounts of protein and energy and would at the same time be of suitable bulk and of such a character as to exert no injurious action upon the animal.

As a matter of fact, we have no such exact knowledge. Practically, animals vary in their requirements, while feeding stuffs of the same name show a wide range in composition, digestibility, and nutritive value. Furthermore, what is still more important, the economic conditions vary from case to case so that, for example, a very liberal ration might be advisable in one instance, while for the same animal under different conditions it would be highly uneconomic. The figures given on previous pages can not be made the basis of infallible recipes which shall save the user the trouble of observing and thinking.

But notwithstanding all this, the foregoing data can afford valuable aid to the feeder. By their use he can get a general idea of the feed requirements of his animals and can compute a ration which will approximately supply the requisite amounts of protein and energy. His ability as a feeder will be shown, first, in his power to estimate the conditions which will modify the feed requirements of his particular animals and cause his feeds to vary from the average, and, second, in the skill with which he can interpret the daily results and modify his feeding in accordance with them.

The problems given on the following pages are intended simply as illustrations of the method of using the tables and not as model rations. Limitations of space forbid the multiplication of examples, but the reader who grasps the method will have no serious difficulty in applying it to his own conditions, while facility will be acquired with surprising rapidity by practice. It will be observed that the form of these tables and the methods of computation do not differ materially from those which have been used for many years in computing rations on the basis of "digestible nutrients," although the significance of some of the figures is different. It may be added that the digestible protein in the tables is true protein—that is, it does not include the so-called "amids" of the "crude protein." Consequently the percentages, as well as the amounts estimated in the rations on succeeding pages, are somewhat smaller than in the older tables.

TOTAL FEED REQUIRED.

A bunch of "feeders" 2 to 3 years old, averaging 1,000 pounds per head, are to be fattened on clover hay and corn-and-cob meal. Such cattle, if of good grade, should weigh 1,400 pounds each when ready for market and should not require over two hundred days to make the gain of 400 pounds. They should therefore make an average gain of 2 pounds per day.

On page 18 it was estimated that a gain of 1 pound live weight requires about 3.5 therms energy value in the feed; for a daily gain of 2 pounds, therefore, the energy requirement would be 7 therms. To this must be added the maintenance requirement, which will increase as the animals grow heavier. For the average weight of 1,200 pounds it is sufficiently accurate to use the maintenance requirement computed in the table on page 16 for 1,250 pounds, viz, 7 therms. This makes the total energy requirement per day 14 therms on the average of the whole feeding period.

If we assume that 2 pounds of grain will be fed for each pound of hay, it is easy to compute from the figures in the last column of the table on page 15 the amount of feed required to supply 14 therms of energy, as follows:

	Therms.
In 100 pounds of clover hay	34.75
In 200 pounds of corn-and-cob meal	144.10
In 300 pounds of feed	178.85
In 1 pound of feed	.596

To supply 14 therms requires 14÷0.596=23.49 pounds of total feed, consisting of 7.83 pounds of clover hay and 15.66 pounds of corn-and-cob meal, or, in round numbers, 8 pounds of hay and 16 pounds of meal.

This, of course, represents the average ration for the whole feeding period. At the beginning the feed will naturally be lighter and consist to a larger extent of hay, while the amount of feed, and especially the proportion of grain, will be gradually increased until toward the end of the feeding the animals are consuming all the grain they will take, with only enough hay to insure the necessary bulk and proper digestion. Naturally, too, the form in which the corn is given will usually be varied in the course of the feeding.

IMPROVEMENT OF A RATION.

In the foregoing example it was assumed that the feeding stuffs to be used had been decided upon and attention was directed simply to the quantity required. Let us now take up the question from the other end and see whether a study of the ration may not yield some suggestion of possible improvement.

According to the table on page 15, clover hay and corn-and-cob meal, respectively, contain in 100 pounds—

Feed.	Total dry matter.	Digestible protein.	Energy value.
	Pounds.	*Pounds.*	*Therms.*
Clover hay	84.7	5.41	34.74
Corn-and-cob meal	84.9	4.53	72.05

The 8 pounds of clover hay in the ration will evidently contain eight one-hundredths of the amounts given in the table, viz:

84.7 ×0.08=6.78 pounds of dry matter.
5.41×0.08=0.43 pound of digestible protein.
34.74×0.08=2.78 therms of energy value.

A precisely similar computation for the corn-and-cob meal gives the following results:

84.9 ×0.16=13.58 pounds of dry matter.
4.53×0.16= 0.72 pound of digestible protein.
72.05×0.16=11.53 therms of energy.

Adding these amounts, we find that the total ration contains:

Kind and amount of feed.	Total dry matter.	Digestible protein.	Energy value.
	Pounds.	*Pounds.*	*Therms.*
Clover hay, 8 pounds	6.78	0.43	2.78
Corn-and-cob meal, 16 pounds	13.58	.72	11.53
Total	20.36	1.15	14.31

The quantity of energy, of course, corresponds with that estimated to be necessary, because the amounts of feed were fixed upon on that basis. We observe, however, that the amount of digestible protein in the ration is considerably less than is estimated on page 18 to be needed by cattle of this age. A ration like the above might produce fair gains, but it would fail to take full advantage of the capacity of such cattle, for growth and the gain would most likely fall below that which was anticipated. An increase in the protein could be expected to make the ration more efficient. One way of accomplishing this which naturally suggests itself is to feed more clover hay, since it is richer in protein than the meal. This would make the ration more bulky, and the rather low total for dry matter indicates that a moderate increase in this direction is practicable. In the early stages of fattening in particular, at a time when we may suppose that the call for protein is greater than at subsequent periods, a freer use of clover hay would usually be practicable, as well as desirable on the score of economy. Even if we suppose the proportion of hay and grain reversed, however, and the ration to consist for a time of 16 pounds of hay and 8 pounds of meal the digestible protein is after all only slightly increased.

	Pounds.
16 pounds of clover hay contain of digestible protein	0.86
8 pounds of corn-and-cob meal contain of digestible protein	.36
Total digestible protein	1.22

To make any marked change in the ration in this respect, it is evident that we must introduce into it some feed much richer in protein than either of those composing it. On consulting the table it is evident that what we need is one of the by-product feeds like gluten feed or meal, the oil meals, etc., and also that only a small amount of one of these will be needed to effect a marked change in the ration. Thus, if we substitute 2 pounds of old-process linseed meal for 2 pounds of the corn-and-cob meal, the ration will foot up as follows:

Kind and amount of feed.	Total dry matter.	Digestible protein.	Energy value.
	Pounds.	*Pounds.*	*Therms.*
Clover hay, 8 pounds	6.78	0.43	2.78
Corn and-cob-meal, 14 pounds	11.87	.63	10.09
Old-process linseed-meal, 2 pounds	1.82	.55	1.58
Total	20.47	1.61	14.45

Thus at a comparatively small additional expense we are able to improve the ration materially by adding the lacking protein, and there is little doubt that the improved ration would produce a more rapid gain and, under ordinary conditions, a more profitable one as well, either by increasing the total gain or shortening the feeding period.

COMPUTING A RATION FROM GIVEN FEEDING STUFFS.

There are available for a dairy herd field-cured corn forage (including the ears), clover hay, corn meal, wheat bran, and gluten feed. The table on page 15 shows that these feeding stuffs, if of good average quality, will furnish in 100 pounds:

Feed.	Total dry matter.	Digestible protein.	Energy value.
	Pounds.	*Pounds.*	*Therms.*
Corn forage	57.8	2.13	30.53
Clover hay	84.7	5.41	34.74
Corn meal	89.1	6.79	88.84
Wheat bran	88.1	10.21	48.23
Gluten feed	91.9	19.95	79.32

The cows average 850 pounds per head and have produced in previous years an average of 20 pounds of milk per day. According to the table on page 16, the maintenance requirement of such animals per day and head would be approximately—

Digestible protein	pound	0.45
Energy	therms	5.60

For the production of 20 pounds of milk of average quality there would be needed, according to the estimates on page 19:

Digestible protein (0.05×20)	pound	1
Energy (0.3×20)	therms	6

The total feed requirements per day and head are therefore:

	Digestible protein.	Energy value.
	Pounds.	*Therms.*
For maintenance	0.45	5.60
For milk production	1.00	6.00
	1.45	11.60

The problem, then, is to find a mixture of the available feeding stuffs which will yield these amounts of digestible protein and of energy and which shall have a suitable bulk.

The first step in the construction of a ration is to fix upon the amounts of coarse fodders. It is usually desirable to use as large a proportion of these as possible, since they are usually cheaper sources of food than grain. On the other hand, the amount of them which an animal can consume is limited. Much depends upon the individual animals, and the proper amount can only be told by trial, but we should probably aim to get from 12 to 14 pounds of dry matter in the form of coarse fodder. Corn forage being a cheap feeding stuff, we shall naturally use this freely, with probably some hay for variety. By a little trial, we find that 14 pounds of corn forage and 6 pounds of clover hay will give us 12 pounds of dry matter and the amounts of digestible protein and of energy shown below:

Kind and amount of feed.	Total dry matter.	Digestible protein.	Energy value.
	Pounds.	*Pounds.*	*Therms.*
Corn forage, 12 pounds	6.94	0.26	3.66
Clover hay, 6 pounds	5.08	.32	2.08
Total	12.02	.58	5.74

To this we have to add sufficient grain to bring the ration up to the requirement. The proper amount we must ascertain by trial. We will take, at a venture, 5 pounds of corn meal and 2 pounds of wheat bran. Adding this to the ration we have:

Kind and amount of feed.	Total dry matter.	Digestible protein.	Energy value.
	Pounds.	*Pounds.*	*Therms.*
Corn forage, 12 pounds	6.94	0.26	3.66
Clover hay, 6 pounds	5.08	.32	2.08
Corn meal, 5 pounds	4.46	.34	4.44
Wheat bran, 2 pounds	1.77	.20	.96
Total	18.25	1.12	11.14

Comparing these totals with the requirement as computed, we find that the ration is slightly deficient in energy and considerably so in digestible protein, while the rather low figure for dry matter shows that more feed may be added to it if desirable. Of the feeding stuffs available, gluten feed is the one richest in protein, and we naturally use this to make up for the lack of this material. We still need 0.33 pound of digestible protein in the ration, and this will be almost exactly supplied by 1½ pounds of gluten feed. Making this addition, the ration stands thus:

Kind and amount of feed.	Total dry matter.	Digestible protein.	Energy value.
	Pounds.	*Pounds.*	*Therms.*
Corn forage, 12 pounds	6.94	0.26	3.66
Clover hay, 6 pounds	5.08	.32	2.08
Corn meal, 5 pounds	4.46	.34	4.44
Wheat bran, 2 pounds	1.77	.20	.96
Gluten feed, 1½ pounds	1.38	.30	1.19
Total	19.63	1.42	12.33

This ration contains almost exactly the desired amount of digestible protein, but it supplies a surplus of energy which would probably tend to fatten the cows rather than to cause any marked increase in the milk flow. We wish, therefore, to reduce the energy content while retaining the same amount of protein. We can do this by taking out some material, such as corn meal, which supplies chiefly energy, and substituting for it a smaller quantity of some substance like gluten feed, rich in protein. Thus, exchanging 1 pound of corn meal for one-half pound of gluten feed gives us a ration which agrees very closely with the computed requirements:

Kind and amount of feed.	Total dry matter.	Digestible protein.	Energy value.
	Pounds.	*Pounds.*	*Therms.*
Corn forage, 12 pounds	6.94	0.26	3.66
Clover hay, 6 pounds	5.08	.32	2.08
Corn meal, 4 pounds	3.56	.27	3.55
Wheat bran, 2 pounds	1.77	.20	.96
Gluten feed, 2 pounds	1.84	.40	1.59
Total	19.19	1.45	11.84

This ration corresponds with the average requirement of the whole herd, since it is based on its average performance. It hardly need be said that it should be modified to suit the requirements and capacities of the individual cows, the heavy milkers getting more and the lighter ones less.

By proceeding in this manner, with a little patience we can usually get a ration corresponding as closely as is necessary to the requirement, provided the feeds available admit of it. With a little experience one very soon learns to guess pretty closely, and with some practice finds the computations very easy. An exact agreement with the requirement need not be sought for, since in practice the composition of the feeds will probably vary more or less from the average of the tables.

THE CHOICE OF FEEDING STUFFS.

When, as in the last example, feeding stuffs must be purchased in order to get the desired relation between the protein and the energy of the ration, it is evident that often a wide range of choice may be offered. In such a case the question at once arises which of the various feeds available is it most economical to purchase, it being evident, of course, that this is not necessarily the one offered at the lowest price.

No simple method of determining this point is possible, because, as we have seen, the food serves two entirely distinct purposes in the body. Sometimes the supply of protein is the specially important point, and in other cases what is needed is a supply of energy without special reference to whether its source be protein or nonnitrogenous material. Consequently, the relative values of two feeding stuffs may vary under different circumstances. Some writers have based their comparisons of the values of by-product feeds solely upon their content of protein, for the reason that such feeds are often bought especially to supply this ingredient, while the fats and especially the carbohydrates are usually produced in abundance upon the farm. They regard that purchased feeding stuff as the most economical which furnishes a pound of digestible protein at the lowest cost, ignoring any value in the other ingredients. It is obvious, however, that this is a one-sided view. The other ingredients have a value, and this is especially true in the case of a feeder who buys a considerable part of his grain supply and depends upon it as a source of energy as well as of protein. The method of comparison illustrated in the following pages is based primarily upon the cost per unit of energy because this is on the whole the most important function of the feed, but the method takes account also of the amount of protein present.

Let us suppose the following feeding stuffs are available to a dairyman at the prices named:

Prices of feeds per ton.

Oats (40 cents per bushel)	$25
Corn meal	25
Wheat bran	21
Wheat middlings	24
Dried brewers' grains	23
Gluten feed	27
Cotton-seed meal	30
Old-process linseed meal	33

The supply of coarse feed on the farm is sufficient to furnish each animal per day 32 pounds of silage and 8 pounds of clover hay; the cows average 1,000 pounds each and may be expected to produce about 24 pounds of milk per day.

The first step is to compute, in precisely the same way as in the previous example, the estimated requirements of these cows per day as follows:

	Digestible protein.	Energy value.
	Pounds.	*Therms.*
For maintenance	0.50	6.00
For 24 pounds of milk:		
Protein 24×0.05	1.20	
Energy 24×0.30		7.20
Total requirement	1.70	13.20

The amounts of silage and clover hay available will furnish, according to the table on page 15, the following amounts of dry matter, digestible protein, and energy value:

Kind and amount of feed.	Total dry matter.	Digestible protein.	Energy value.
	Pounds.	*Pound.*	*Therms.*
Corn silage, 32 pounds	8.19	0.39	5.30
Clover hay, 8 pounds	6.78	.43	2.78
Total	14.97	.82	8.08

The question now is what feeding stuffs is it most economical to buy (or to refrain from selling if in stock) to complete the ration. The first step in deciding this question is to compare the various feeds as sources of energy and see which one furnishes a unit of energy value at the lowest price. This computation gives the following results:

Kind of feed.	Cost of 100 pounds.	Energy value of 100 pounds.	Cost of 1 therm energy value.
		Therms.	*Cents.*
Oats	$1.25	66.27	1.89
Corn meal	1.25	88.84	1.13
Wheat bran	1.05	48.23	2.18
Wheat middlings	1.20	77.65	1.55
Dried brewer's grains	1.15	60.01	1.92
Gluten feed	1.35	79.32	1.70
Cotton-seed meal	1.50	84.20	1.78
Old-process linseed meal	1.65	78.92	2.09

Evidently, if it were simply a question of supplying energy to the animals, we should use corn meal, since that supplies a unit of energy at a much lower price than any of the other feeding stuffs. If it were thought desirable to add variety to the ration, wheat middlings would obviously be our next choice.

It is evident, however, without going through the labor of computation, that while corn meal and wheat middlings may be used in the ration, neither will supply enough protein if used exclusively. Of the available feeding stuffs which are rich in protein and which may therefore serve to balance the deficiency of this ingredient, gluten feed is relatively the cheapest, and cotton-seed meal comes next. While the difference between the two is not great, we shall naturally try the cheaper one. It is not difficult to determine by a few trials that 4 pounds of corn meal and 2½ pounds of gluten feed, in addition to the coarse fodder available, will give a ration corresponding very closely to the requirements, as the following table shows:

Kind and amount of feed.	Total dry matter.	Digestible protein.	Energy value.
	Pounds.	*Pounds.*	*Therms.*
Corn silage, 32 pounds	8.19	0.39	5.30
Clover hay, 8 pounds	6.78	.43	2.78
Corn meal, 4 pounds	3.56	.31	3.55
Gluten feed, 2½ pounds	2.30	.50	1.73
Total	20.83	1.63	13.36

This ration shows as close an agreement with the computed requirement as could be desired. The comparatively low figure for dry matter indicates that more coarse fodder might have been used had it been available, with the probable effect of cheapening the ration. As it is, we have used the feeds relatively lowest in price and apparently have a very economical ration.

Since, according to the assumed figures, corn meal is relatively cheap as compared with the other feeding stuffs, we shall naturally try to use as large a proportion of this in the ration as practicable. In order to increase the corn meal, however, it will plainly be necessary to use some other feed richer in protein than gluten feed. Cotton-seed meal is nearly as cheap as a source of energy as gluten feed, while it contains almost twice as much protein. We therefore try the effect of increasing the corn meal to 4½ pounds and using 1½ pounds of cotton-seed meal in place of the 2½ pounds of gluten feed, with the following results:

Kind and amount of feed.	Total dry matter.	Digestible protein.	Energy value.
	Pounds.	*Pounds.*	*Therms.*
Corn silage, 32 pounds	8.19	0.39	5.30
Clover hay, 8 pounds	6.78	.43	2.78
Corn meal, 4½ pounds	4.01	.31	4.00
Cotton-seed meal, 1½ pounds	1.38	.54	1.26
Total	20.36	1.67	13.34

This ration agrees with the computed requirements even better than the previous one, while a simple comparison shows that it is actually a trifle cheaper. The grain portion of the two rations costs as follows:

Feed in ration.	First ration.	Second ration.
	Cents.	*Cents.*
Corn meal	5.00	5.63
Gluten meal	3.37	....
Cotton-seed meal	....	2.25
Total	8.37	7.88

It thus appears that a ration made up with the somewhat more expensive cotton-seed meal was actually cheaper because it was possible to use more of the cheap corn meal. The difference, to be sure, is small, yet for 30 cows fed for 200 days, it would amount to $30. Such a difference is only likely to be found, however, when, as was assumed in this instance, some feed low in protein but rich in energy can be had at a relatively cheap rate. In general, it may be said that when there are no very marked differences in the cost of a therm of energy value in the feeding stuffs constituting the bulk of the ration one of the various high-protein feeds which supplies energy at the lowest cost should ordinarily be used, although it is always wise to check up this point, as in the example just given.

THE COMPOUNDING OF RATIONS.

While in the foregoing examples an exact daily ration is computed, it would, of course, be utterly impracticable in most cases to weigh out separately each day's ration for each animal. Individual weighings of feeds at intervals would often yield valuable information and might be profitably undertaken, but for the ordinary routine of feeding simpler methods must be used.

When practicable, the grain feed may be advantageously mixed in advance in the desired proportions in as large quantities as the storage capacity available and the proper preservation of the materials will permit. Where facilities are available, the whole amount of grain required for all the animals may be weighed out daily, or even for each feeding, without much additional labor. In distributing the grain to the individual animals, regard of course should be paid to their productive capacity and their individual peculiarities. The ration, as computed, is for the average animal. The skill of the feeder is shown in adapting it in quality and in amount to the individual. Doubtless individual weighings at intervals, as already suggested, would be useful as a control on the accuracy of the distribution.

The weighing of coarse fodder is usually a more difficult problem on account of its bulk. When, however, silage or cut fodder is handled in trucks, the matter is still comparatively simple. Long fodder, on the contrary, is not readily weighed. Nevertheless, even here an occasional weighing, if practicable, as a control upon the feeding, is very desirable.

In all these and similar matters common sense is necessary. The computed ration expresses the best estimate that can be made of the actual average requirements, but it is at best more or less of an approximation. It would be foolish, therefore, to seek extreme exactness in realizing it or to go to more expense in the weighing and apportioning of the feed than the saving in the latter would amount to. The scale upon which the feeding is conducted will play an important part. Where scores or hundreds of animals are being fed, an exactness may be profitably sought which would be absurd in the case of two or three animals. Finally, it should be remembered that these computed rations are guides and not recipes. They may aid the feeder in wisely using the resources at his command, but they can not take the place of experience and good judgment.

BEARING ON FARM MANAGEMENT.

The data and the methods of computation on previous pages will aid the feeder in determining the amounts of each class of feeds needed for each class of his animals. The man of good business habits will find them useful in determining the quantities of each kind of feed to grow or purchase and in deciding upon the purchase of animals to feed and the feeds to keep or to purchase for feeding them. These facts and methods will aid the farmer, the feeder, or the user of work animals in deciding upon the chances of profit in proposed enterprises. Often by using these formal ways of checking up a proposed business project the way is made more clear to avoid loss and to secure the largest practicable profit. In case of the farmer who grows most of his feed stuffs, these facts and methods of calculation may often be used in connection with the planning of his scheme of crop rotation and in proportioning the acreages of the respective crops to each other and to the numbers of each class of animals. They will prove useful in reducing the farm-management plan to a scientific basis.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 347.

THE REPAIR OF FARM EQUIPMENT.

BY

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., April 2, 1908.

Sir: I have the honor to transmit herewith a manuscript entitled "The Repair of Farm Equipment," by Mr. W. R. Beattie, Assistant Horticulturist, and recommend that it be published as a Farmers' Bulletin.

The proper care of farm equipment is a matter of great importance, not only to obtain the greatest efficiency of the machinery and implements, but also to lengthen their period of service and lessen the cost of maintenance.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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THE REPAIR OF FARM EQUIPMENT.

INTRODUCTION.

The successful management of a modern farm depends largely upon the efficiency of the equipment with which the work is performed. The equipment of the average farm can be divided into about three more or less distinct classes, as follows: First, and most important, are the buildings, fences, implements, machinery, wagons, and all appliances used in the more important farming operations; second, utensils and machinery used in connection with the dairy, garden tools, butchering outfit, and the numerous small things for general use about the place; third, the tools, materials, and facilities for keeping the first two classes of equipment in repair and in good working order. It is with the last class that this paper has to deal, the object being to assist the farmer in the selection of a suitable tool outfit, to suggest a line of supplies that are most commonly required for making repairs, and to give hints regarding the proper care and uses of tools.

In order to secure the greatest efficiency, all implements and machinery should be properly housed when not in actual service, so as to be in good working condition when required for use. Alterations and repairs on buildings and fences are required from time to time to accommodate them to changed conditions and to protect the crops. Farm machinery and equipment generally are subject to wear and breakage, and constant attention to repairs is necessary. The extent to which the repair work should be done on the farm will depend entirely upon local circumstances. If there is a well-equipped shop near-by where the repair work can be done by a trained mechanic without loss of time it may be best to carry the greater part of such work to the shop; but if the shop is at a distance, is poorly equipped, or, as is often the case, the mechanic in charge is incapable of turning out good work, it will then be a saving to perform the work at home. Besides, there is a large amount of repair work that can not be carried to a shop and must be done on the farm if it is done at all.

The importance of making repairs promptly.—Breakdowns are most frequent during the busy season, and much valuable time may be lost in going to some distant shop for repairs or in waiting until a new part of some machine or implement can be secured. In many cases an accident to one of the farm implements will cause the loss of not only a portion of the crop but also the time of a number of farm hands until repairs can be made and work resumed. Permanent repairs can frequently be made at once, and under most circumstances temporary repairs, at least, can be made, provided the necessary tools and supplies are at hand.

The economy of making repairs on the farm.—The question as to how far to undertake to do repair work on the farm will depend considerably upon the personality of the farmer himself and his capability to handle tools and execute the work. The regular work of the farm should be the primary consideration, and any repair or construction work that will cause the neglect of crops should not be undertaken. By the aid of a little training, together with the necessary tools and supplies, the farmer can repair all ordinary injuries to the farm equipment; and as a rule he can do this in a shorter time than would be required to go to a distant shop. If it were not for the economy of time, repairs made in a regular shop and by a trained mechanic would generally be found more satisfactory than those made at home, but the saving in both time and expense renders the repair outfit an important adjunct to the farm equipment.

The time for making repairs.—Much of the loss and annoyance from breakage may be avoided by carefully inspecting and mending weak parts of the farm equipment before the rush of the season's work begins. The proper time for making such repairs as may be anticipated is during the winter months and at times when the regular farm work is not pressing. As the season advances the implements that will be required for the next farming operations should be gotten out, gone over, and given any attention required to make them ready for immediate use. If the farm machinery is not properly housed through the winter or during other periods of disuse, then it is all the more important that it should be given a careful overhauling. After inspecting an implement, tightening bolts, strengthening weak parts, and renewing broken pieces, any necessary painting should be done. Frequent applications of dark red metallic paint, consisting either of red lead or Venetian red and raw linseed oil, not only improve the appearance of many of the farm implements but add greatly to their lasting qualities. This is an age when appearances count for much, and a farmer's standing in the community is frequently governed by the appearance of his farm equipment. The man who spends his spare moments in the repair of fences and gates and in maintaining a neat appearance of the entire farm will easily be a leader among his neighbors.

The educational value of the use of tools.—The use of tools is of great value as an educational feature, especially when the work is carefully performed. The boys on the farm should be encouraged in the use of tools, but should be held responsible both for the care of the tools and the character of the work performed with them. The tool outfit of the farm is of special service on stormy days and will aid greatly in keeping the boys employed and contented to remain at home.

Before beginning any piece of work, a definite plan should be worked out in detail, and if it requires the assembling of several parts each piece should be sketched on paper or on a board, so that when finished a close fitting of parts will be assured. It may be well to add a word of caution regarding the improper use of tools, for constant tinkering will work more harm than good. If a bolt is tight, that is sufficient, and an extra turn with the wrench may strip the threads and cause trouble. The taking apart of machinery should be avoided, except in cases where it is absolutely necessary to do so. The reaper and mower and other machines of this class are securely put together at the factory, and if the parts are removed it is difficult to restore them to their proper adjustments.

It is doubtful whether horseshoeing,[a] wheelwright work, and repair work which requires special machinery can be economically performed on the farm, except where the farming operations are sufficiently extensive to justify the establishment of a shop and the employment of a mechanic.

TOOLS ADAPTED TO REPAIR WORK ON THE FARM.

The selection of the tool outfit will depend upon the scope and character of the work to be performed.

On most farms there is a deficiency of suitable repair tools and supplies, and an increased investment along this line is strongly recommended. Some farmers, however, need to be cautioned against hasty, indiscriminate purchases. A small, well selected outfit, used to the best advantage and well cared for, will prove more satisfactory than a large miscellaneous assortment improperly kept and used.

In this bulletin no attempt is made to determine the extent of the repair outfit which the individual farmer should purchase or the amount and scope of the work he should undertake. The problem is one for each farmer to solve, as he alone is familiar with all the conditions. The aim here is to furnish information which will be useful to farmers of all classes in selecting repair outfits, whether they be large or small, leaving each farmer to decide the extent to which he should purchase and use the tools and supplies listed.

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[a] For information on horseshoeing, see Farmers' Bulletin No. 179, which will be sent free upon request to the Secretary of Agriculture.

In nearly all localities most of the tools may be purchased from the local hardware dealer. In many places there are stores known as "farmers' supply houses" from which many of the more common tools may be purchased. In addition to these, many of the manufacturers of tools offer combination outfits, and the large "mail-order" houses of the country are prepared to supply tools of all kinds, either singly or in combinations. A number of tools and appliances described herein are not ordinarily found in the regular stores, and these can be made either by a local mechanic or on the farm.

Under most circumstances it will pay to secure tools of good quality, although fine exterior finish is not essential. Tools of very inferior quality are offered at low prices, but they invariably prove a disappointment to the purchaser. The name of the manufacturer is a sufficient guaranty of the quality of many tools, and the purchaser is advised to secure only those that are sold under a guaranty from either the manufacturer or the dealer. When contemplating the purchase of a collection of tools, make a careful study to see just what ones are needed, then purchase all at one time, and a liberal discount can generally be secured.

For the convenience of intending purchasers in making up a set of tools, lists with descriptions of those most commonly required on the farm are here given; also suggestive combinations varying in price from $2.50 to $25. In describing the tools, they have been divided into classes, including wood-working, iron-working, miscellaneous; and general-purpose tools, and special conveniences for repair work. In making up the lower priced combinations, preference is given to the tools required for the more simple operations and having a broad range of utility.

WOOD-WORKING TOOLS.

In the case of certain tools more than one shape or style is offered by dealers. In a few cases a particular type of tool is better adapted to use on the farm than others, and these differences are mentioned in connection with the following list.

Ax.—An ax is perhaps one of the first tools required upon a farm. The ax properly belongs to the regular farm equipment, but inasmuch as an ax which is used for general purposes on the farm is rarely in condition for use in making repairs, it is recommended that at least two axes be on hand, one to be kept in first-class condition and to be used for repair and construction work alone. Axes are of various grades and range in price from 75 cents to $1.50. Axes also vary in weight between 2 and 5 pounds, $4\frac{1}{4}$ or $4\frac{1}{2}$ pounds being a good size for general use. It always pays to secure a good ax, and a hand-made hickory handle is to be preferred to the cheaper machine-made ones.

Hand ax.—The tool commonly known as a hand ax is similar to a large hatchet or, rather, is a compromise between a hatchet and a broadax. The blade of the hand ax is ground on one side only, and it is especially adapted for use in hewing the side of a post and for "roughing out" doubletrees, tongues, and similar parts of machinery.

Hatchet.—A hatchet is almost indispensable on the farm, even where the tool outfit is very limited. There are several styles and shapes of hatchets on the market, the half-hatchet (fig. 1, *B*) being perhaps the most serviceable type. There is no tool where quality counts so much as in the hatchet; however, a good one can be secured for about 75 cents.

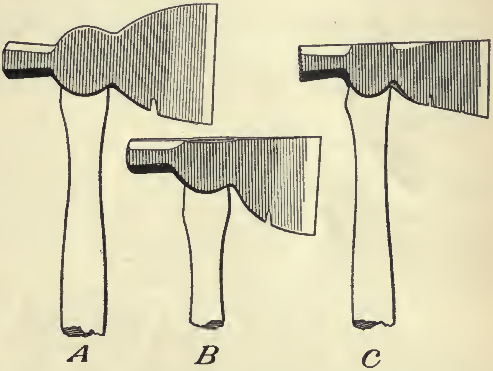

FIG. 1.—Three types of hatchet. The half hatchet (*B*) is best adapted for general farm use.

Handsaws.—A good handsaw is almost as important on the farm as an ax or a hatchet. A crosscut saw, having regular V-shaped teeth, is most often required, but a ripping saw will be desirable where a large amount of lengthwise sawing is to be done. The difference in the shape of the teeth of the crosscut and ripping saws is shown in figure 2. A crosscut saw for general farm purposes should not be too fine, one having about 8 teeth to the inch being desirable. If more than one saw of this class is kept, the collection should include a No. 7 or No. 8 for the rougher work and a No. 11 for finer cutting. A large-toothed crosscut saw can readily be used in place of a ripping saw, especially if the teeth are filed a trifle on the order of those of the ripping saw.

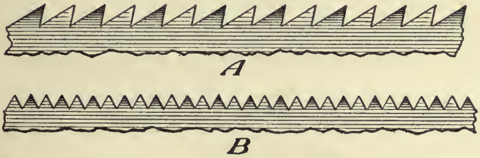

FIG. 2.—Saw teeth : *A*, ripping saw ; *B*, crosscut saw.

The proper sharpening of saws is essential, and unless one has had considerable experience it will be desirable to have this work performed by a trained mechanic. The saw-sharpening outfit consists of two thin boards between which the saw blade can be clamped in the vise or workbench clamp, a "set" for use in giving the teeth of the saw the proper spread, and a small three-cornered file. First go over the teeth of the saw with the "set" and open them just enough to give the blade clearance in the wood, being careful to spread the teeth in the same direction as they were originally. After having properly opened the teeth proceed to sharpen them with the small three-cornered file. Hold the file with both hands, at a slight angle with the saw, and draw it about twice through each notch between the teeth. File one side of the saw at a time, skipping every other notch; then reverse the blade and file the other side. It should be the aim to retain the shape and pitch given the teeth in the factory.

Compass saw.—The compass, or bracket, saw is a narrow saw blade tapering to a point. The principal uses of a compass saw are for cutting curved surfaces for the timber parts of implements, sawing circular openings, and sawing a slit from an auger hole in which the regular handsaw may be started.

Steel square.—For most purposes a square having a length of 24 inches on one arm and 16 or 18 inches on the other arm will be found satisfactory. For lighter work a medium-sized square is convenient, and for very small and careful marking the try-square, measuring about 4 by 6 inches, is desirable. The standard-size square will be found most important, and this can be secured at prices ranging from 75 cents to $1.50, or even higher. A small try-square can be purchased for 25 or 30 cents.

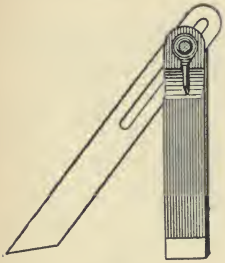

Fig. 3.—Bevel square.

Bevel square.—The bevel square (fig. 3) is a device one blade of which can be set at any angle to the other. This tool is useful where a number of pieces of material are to be cut to a given slope, the siding for the gable end of a building being a good example. The cost of a bevel square should be about 40 cents.

Drawing knife.—The uses of this implement on the farm are too well known and numerous to require mention. The essentials of a serviceable drawing knife are good steel in the blade and substantial handles securely riveted. A first-class drawing knife adapted to general purposes can be secured for about $1.

Brace and bits.—For boring holes not exceeding 1¼ inches in diameter, a brace and a set of bits are essential. There are several types of brace upon the market. The simpler forms can be secured for 40 or 50 cents each, while the more elaborate types with ball bearings and ratchet shank frequently sell as high as $2.50. For ordinary work the cheaper form of plain brace will answer, but for boring in close quarters a ratchet brace that will work without turning the handle completely around is desirable.

The bits for use in the brace can be secured singly or in sets of 6, 8, or 12, including sizes ranging from one-fourth inch to 1¼ inches. A set containing eight bits will answer practically every requirement on the farm. The set containing twelve bits includes sixteenth-inch sizes and can be secured at prices from $2.50 upward. The brace and a full set of bits should not cost more than $5.

Gimlet bits.—For boring small holes in wood, especially for the insertion of wood screws, an assortment of gimlet bits is desirable. The uses of the gimlet bits are limited, however, and their place may be filled by the small sizes of twist drills which may be used for boring either wood or metals.

Screw-driver bit.—For setting wood screws in hard wood or for the removal of old ones there is nothing equal to a square-shank screw-driver that may be used in the brace. This little tool can be made from the shank of a broken carpenter's bit, from an old file, or a small piece of steel, or it can be purchased for 10 cents.

Screw-driver.—The common hand screw-driver is especially desirable for use about the dwelling and for light work on machinery. In order that a screw-driver should give good service it is essential that the metal part should consist of good steel and that it should extend through the handle and be securely riveted. The handle should also be protected from splitting by means of bands or rivets. This type of tool can be secured at prices ranging from 25 to 75 cents, according to size and quality.

Augers.—For boring holes larger than 1¼ inches in diameter it will be necessary to secure regular augers having T-style handles. By having the square shank of the augers of the same size and provided with a thread and nut at the end, one handle can be made to serve for all. There are handles on the market which are provided with an iron plate and thumbscrew for clamping to the auger shank.

If the cutting edges of an auger or a bit become dull, they may be sharpened with a small file. To merely sharpen an auger, file on the lower side of the cutting edges, being careful to keep them of the same pitch or bevel. In case a bit does not take sufficient hold, first see that the threads on the center point are clean; if the difficulty is not with the threads, then file the upper side of the cutting edges a little.

Jack plane.—The name "jack plane" is applied to that class of planes that are suited for general purposes, especially for rough work. The old form of wood-body jack plane with its wedge-set bit has been largely replaced by the more modern iron or combination wood and iron plane, with spring clamp and thread feed to regulate the bit. A very good 14-inch jack plane can be bought for $1.50.

Smoothing plane.—This tool is similar to the jack plane except that it is smaller and is designed for imparting a smooth finish after the rougher surface has been removed. The cost of a smoothing plane will be about $1.25.

In grinding the bit of a plane care must be taken to keep the edge square and to prevent the corners from becoming rounded. It is well to have a small square at hand and try the edge from time to time while grinding. After grinding the plane bit always finish on an oilstone, smoothing off any burr or rough edge that has been formed in grinding. Do not grind the plane bit every time it loses its keen edge, but simply whet it on the oilstone; grind it only when the oilstone fails to give a cutting edge. In resetting the bit in its place, first have the cutting edge of the bit a little higher than the lower surface of the plane, then after clamping it in place gradually feed it downward until the proper depth of cut is reached.

Wood chisels.—A number of chisels of sizes from one-half inch to 1½ inches are desirable. The type known as "socket and firmer," with a leather tip on the wood handle, is the best for general purposes. The price will vary with the size and quality from 25 cents to $1.50 each. A wooden mallet should be used for driving the chisels.

Claw hammer.—This common type of hammer is desirable for use around the house and outbuildings. The principle of construction gives great leverage for drawing nails. If a spike or long nail is to be drawn, the efficiency of the claw will be greatly increased by placing a rounded block of wood between the hammer and the plank from which the nail is being drawn. A medium-grade claw hammer can be secured for about 50 cents, but one of the highest quality will cost 90 cents to $1.

Claw bar.—Where a great many large nails are to be drawn or where old buildings are to be torn down, there is nothing superior to a claw bar (fig. 4). This tool can be made by any blacksmith from a piece of three-fourths or seven-eighths inch steel about 3½ feet in length. One end should be shaped somewhat like the claw of a hammer with a wedge-shaped slit for taking hold of nails. The opposite or handle end may be drawn to a chisel point, and serve as a bar for the prying apart of materials; or if drawn to a sharp point it is very useful for drawing staples. The length of handle and short fulcrum of this tool give a powerful leverage when applied to the pulling of spikes or bolts.

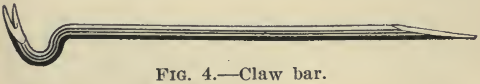

FIG. 4.—Claw bar.

Spokeshave.—The spokeshave (fig. 5), sometimes called a scraper, has been in general use for a long time and is still one of the most useful tools, especially in the finishing of handles or anything that is shaved from wood. A good one can be purchased for 40 cents.

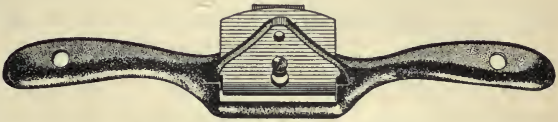

FIG. 5.—Spokeshave, or scraper.

Wood rasp.—The wood rasp is similar to a coarse file and is used for finishing any piece of wood which requires to be brought to a definite size. A wood rasp is desirable for use in fitting the handles of picks, mattocks, or hoes to their sockets. A 14-inch wood rasp will answer general purposes and should cost about 35 cents.

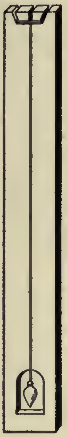

FIG. 6.—Plumb rule made from a piece of board.

Folding rule.—Where some measuring device is frequently wanted, a folding rule that can be carried in the pocket will be found very convenient. Folding rules are made in lengths from 1 to 5 feet and can be secured as cheaply as 10 cents each, but one that will prove durable will cost 35 or 40 cents.

Chalk line.—Any hard-twisted string will serve as a chalk line. Cord made especially for this purpose can be secured for 10 or 15 cents a ball. Chalk for use on the line can be purchased for 5 cents a ball, or about 15 cents a pound. A chalk line is especially desirable for securing a straight cut through a plank having irregular edges and in "laying off" a tapering tongue or similar part of farm machinery.

Plumb rule.—A plumb rule is desirable for use in construction work and is also adapted to the setting of posts. A device of this kind (fig. 6) can be made from a piece of board, a bob, and a string.

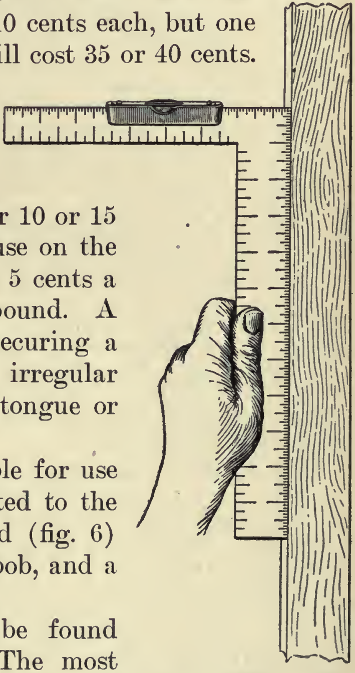

FIG. 7.—Spirit level used as a plumb.

Spirit level.—This implement will be found useful for a great many purposes. The most common form of spirit level consists of a bar of wood with a spirit tube mounted near the center. In the better grades a plumbing tube is inserted near one end. Levels of this kind cost from 40 cents to $1.50 each. There is a small, or pocket size, level (fig. 7) that is adapted for fastening on a steel square and may be used either for leveling or plumbing purposes. This form of level can be bought for 15 or 20 cents.

TOOLS AND EQUIPMENT FOR WORKING IRON.

The following list, together with short descriptions, includes the majority of the tools that will be required for handling metals in the repair of farm equipment. There are a few tools that are equally useful for working with both wood and metals; for instance, twist drills may be employed for boring almost any kind of material.

Riveting hammer.—A good riveting hammer is essential on every farm where modern machinery is used. There are two types of riveting hammer in general use (fig. 8), one having one end of wedge shape and the other type (known as a machinist's hammer) having a round end for riveting purposes. The hammer having the wedge-shaped riveting end is generally considered best for farm purposes.

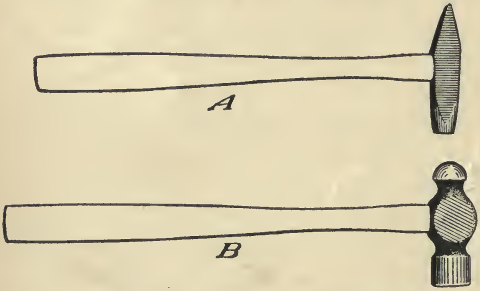

FIG. 8.—Riveting hammers: *A*, ordinary riveting hammer; *B*, machinist's hammer.

Monkey wrench.—A monkey wrench frequently accompanies one or more of the farm machines, but as this is one of the most important repair tools an extra one will not come amiss. The size of this tool is determined by its length in inches, a 12-inch monkey wrench being adapted for most purposes. The type of wrench having the wood handle in two parts and riveted to the central iron handle is most serviceable. A 12-inch monkey wrench will cost about 60 cents.

Solid or end wrenches.—For many purposes the solid type of wrench (fig. 9) with end jaws fitted to the various sizes of bolts and nuts is desirable. Those made somewhat in the shape of the letter S are adapted to working in close places and are not likely to slip. These wrenches may be purchased at prices ranging from 7 to 35 cents each, or they may be made from steel and slightly hardened.

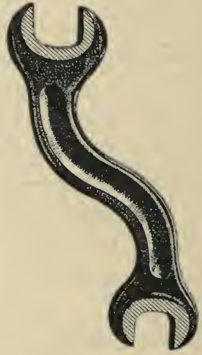

FIG. 9.—Solid, or S, wrench.

Alligator wrench.—The alligator wrench is very desirable for holding a round-headed bolt or rod of iron; also for turning nuts that are inaccessible for an ordinary wrench. Alligator wrenches having one jaw adjustable are obtainable, but the form having both jaws rigid is somewhat cheaper. The cost of a small alligator wrench will be anywhere between 15 and 60 cents, according to quality and finish.

Pipe wrench.—A pipe wrench of 10-inch or 12-inch size is quite desirable for use in making repairs upon farm machinery. The pipe wrench (fig. 10) is adapted for turning or holding iron pipe, rods, or bolts. It is essential to have one or more pipe wrenches on farms where a water supply under pressure and general plumbing appliances are maintained; however, wrenches for pipe fitting should as a rule be somewhat larger than those used for repair work on machinery. The cost of a small pipe wrench suitable for repair work should be about $1. Neither the pipe wrench nor the alligator wrench should be used extensively for turning the nuts of bolts, as the teeth of these wrenches tear and injure the nuts.

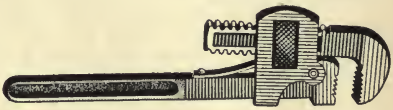

FIG. 10.—Pipe wrench.

Punches.—An assortment of punches, including several sizes and kinds, should be kept on hand. The round, solid-point punch, adapted to such work as punching out the rivets of the ordinary mowing-machine knife, is the most important, although those having square and taper points are frequently required. The collection should include a center punch having a blunt, sharp point for marking metals before drilling.

An assortment of punches may be purchased at a cost of from 10 to 40 cents each, or they may be made from tool steel by a blacksmith.

Cold chisels.—For general-purpose repairing an assortment of various sizes of cold chisels should be kept on hand. These tools belong in the same class as the punches and can either be purchased or made from tool steel. The cost of cold chisels varies according to the amount of steel that they contain, the smaller ones being sold as low as 15 cents and the larger ones from 40 to 60 cents.

A chisel for use in cutting hot iron known as a " hardie " (shown in place on anvil, fig. 12) is designed to fit the square hole in an anvil, the iron being laid upon the upturned edge of the hardie and struck with a heavy hammer. Another type of cutter fitted with a handle is offered by the trade. In using this tool the iron is placed upon the anvil, the cutter is held in position, and the cutting is done by striking with a sledge or heavy hammer. The cutting edge of any chisel for cutting iron requires to be tempered very carefully in order that it may withstand hard usage.

Files.—Both flat and three-cornered files will be required quite frequently in making repairs or improvements to equipment. A large flat file can be secured for 30 or 40 cents, and the small three-cornered ones will cost only 10 or 15 cents each. In securing a large flat file it is desirable that it should not be too fine, one of the flat bastard type being the most serviceable. The three-cornered files can be secured with single or double cutting ends. Square and round, or rattail, files are useful for many purposes.

Forge.—There are numerous makes of portable forges on the market, practically all of which are adapted to use on the farm. This type of forge is desirable where it is necessary to do work in several localities; but where the repair work can all be brought to a central shop a stationary forge with rotary blower will be found most satisfactory. Portable forges (fig. 11) can be secured at prices ranging from $3.50 to $15, a good outfit being obtainable for about $8. A blower with connections for a stationary forge can be bought for $10 to $15.

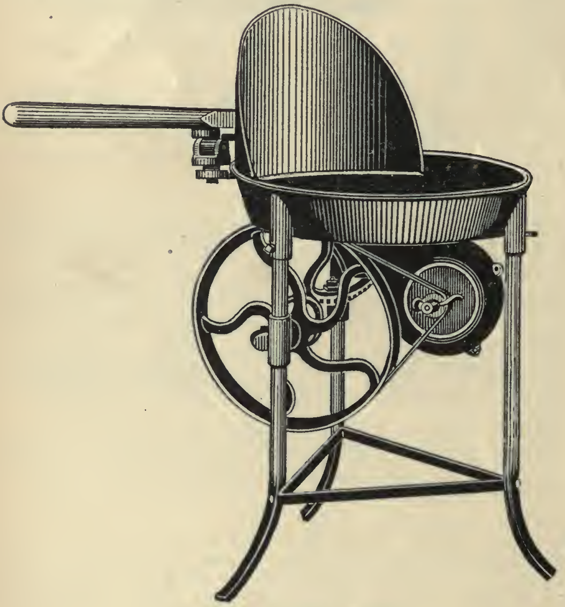

FIG. 11.—Portable forge.

Anvil.—Some form of anvil is of as much importance as the forge. Anvils are made in various sizes and are sold by weight. Two types of anvil are offered by dealers, the one consisting entirely of wrought steel and the other of cast iron with a steel facing. The wrought anvil, although more expensive, is to be preferred to the cast-iron type, as there is no danger of its breaking under heavy forging. An anvil suited to repair work should weigh from 70 to 90 pounds. The cost of a cast anvil will be about 3 cents a pound and of the wrought-steel anvil 10 or 11 cents a pound.

Where no regular blacksmith outfit is maintained, a combination vise and anvil will be found fairly satisfactory. The anvil should be mounted on a heavy block of wood, but in order that it may be moved when necessary it should not be anchored to the floor.

Blacksmiths' hammers.—A forging hammer weighing about 2 pounds will be desirable for working hot iron on the anvil. This tool will cost from 80 cents to $1.

Where considerable heavy ironwork is to be performed, it will be desirable to secure a sledge hammer weighing about 8 pounds, to be used by the person assisting the blacksmith. This tool is known as a "striking" hammer. The cost of an 8-pound sledge complete with handle will be about $1.

Tongs.—At least two pairs of tongs will be required for blacksmith work. If more than two pairs are provided the collection should include those having broad, flat jaws, also straight and curved-lip tongs. The size of tongs is determined by their length in inches, the 20-inch length being about right for general purposes. The cost of tongs of this character should not be more than 50 cents a pair.

Vise.—Where considerable forging is to be done a regular blacksmith's vise with wrought-steel jaws is desirable. This type of vise will withstand the heavy hammering necessary to the bending and shaping of iron. For general purposes the cast-iron type known as a bench vise will answer, and this can be procured at a much lower cost than the regular steel vise. A combination pipe-holding and bench vise can be obtained, but the cost of such a tool is almost as great as for both a bench vise and a pipe vise when made separately. A very fair bench vise can be secured for $3.50, a wrought-steel blacksmith's vise will cost about $5.50, and a pipe vise that will hold all sizes of piping from 2-inch down to the smallest can be obtained for $3.

Combination tools (fig. 12) intended to do the work required of a vise, anvil, and drill press are upon the market, but the separate tools will always be found most convenient and durable. A combination tool of this character can be obtained for about $4.

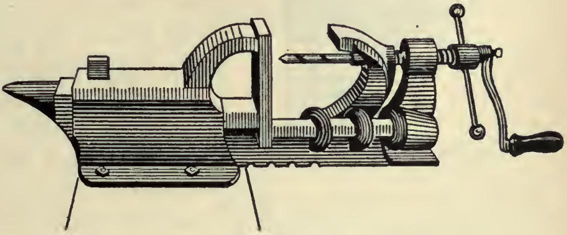

FIG. 12.—Combination vise, anvil, and drill.

Drill press.—Where extensive repairs are to be undertaken, there is no part of the repair outfit more desirable than a good drill press. The possession of some device by the use of which bolt and rivet holes may be drilled in metals renders possible the repair of almost any broken part of an implement. There are several forms of drilling machines upon the market, but a standard drill press (fig. 13) will prove most satisfactory. A machine of this class is suitable for all ordinary purposes and can be secured, exclusive of drills, for about $10. There is a great difference in the quality of drills, but a fairly good set including $\frac{3}{16}$, $\frac{1}{4}$, $\frac{3}{8}$, $\frac{7}{16}$, $\frac{1}{2}$, $\frac{5}{8}$, $\frac{3}{4}$, $\frac{7}{8}$, and 1 inch sizes can be secured for about $5, making the price of the whole outfit $15. A lower priced outfit is obtainable, but the drill press is a machine which with proper care should last a long time, and it pays to secure a good one.

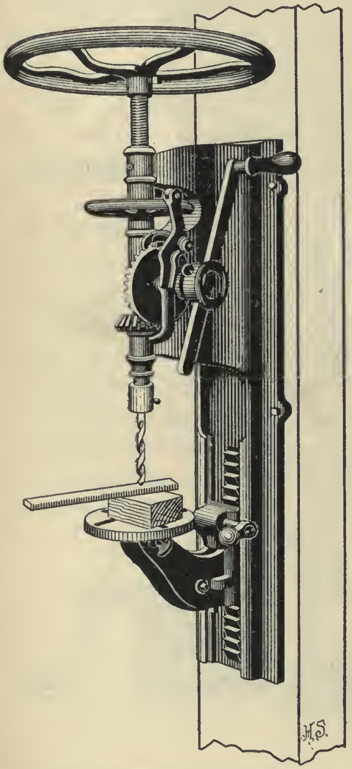

Fig. 13.—Standard drill press.

As a rule the drill press is designed for mounting on a solid post, preferably a support of the building in which the shop is located. In operating the drill press place a small block of wood upon the bedplate and beneath the metal to be drilled. Before starting to turn the drill see that its point is in the center-punch mark, which indicates the location where the hole is to be drilled, and that everything is both level and solid. The drill should be turned slowly and fed downward with regularity. Care must be taken when the drill breaks through the metal that the drill itself does not bind and become broken. When drilling holes in pieces of metal that are too short for holding firmly with the hand, a clamp should be used and the piece of metal fastened firmly to the bedplate.

No one except an expert at grinding should attempt to sharpen the drills, as they must be ground to a particular bevel in order to cut properly. It is best to take them to a machine shop from time to time and have them dressed. Certain drills, such as $\frac{1}{4}$, $\frac{3}{8}$, and $\frac{1}{2}$ inch, are used more often than the others, and it is desirable to have extra drills in these sizes on hand.

In boring wrought iron or soft steel plenty of good oil should be used upon the drill to prevent its heating. Hard steel should not be drilled, or at least not without first removing the temper. Cast iron, brass, and composition metals can be drilled without the use of oil. Always make an indentation with the center punch before starting to drill a hole; this provides a starting point for the drill and insures getting the hole in the proper place.

Ratchet drill.—The place of a drill press may in a measure be filled by the employment of a ratchet drill (fig. 14). This device has the advantage of being portable, and it may also be worked in close quarters where the use of a drill press would not be practicable. In using a ratchet drill as a substitute for the drill press it will be necessary to provide a solid frame for holding it, as shown in figure 14. A common boilermaker's ratchet is obtainable for $4 or $5, but the square-shank drills for use with it are more expensive than the common round and taper-shank drills used in the drill press. The ratchet-drill outfit is not adapted for boring holes that are below three-eighths inch in size, owing to the liability of breaking the drills.

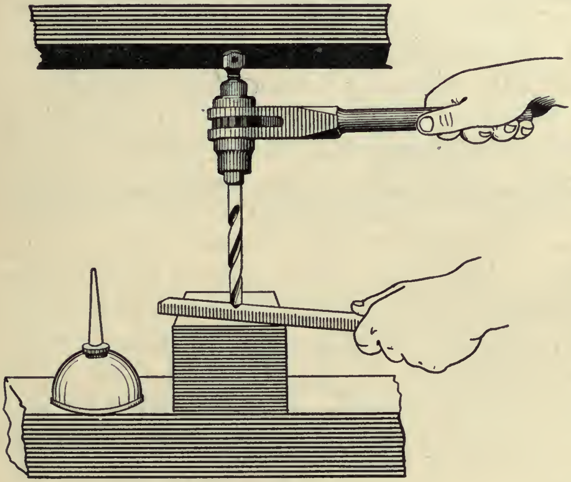

FIG. 14.—Ratchet drill.

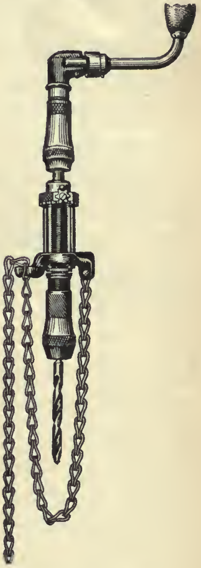

FIG. 15.—Chain drill.

Chain drill.—A small chain drilling outfit which works in an ordinary carpenter's brace is desirable for light work. This device is especially adapted to the drilling of tire-bolt holes and similar work not exceeding three-eighths of an inch in diameter. An outfit of this kind, as shown in figure 15, will cost about $2 exclusive of drills.

Twist drills.—Regular drills for use in boring metals can be secured having square shanks that fit in an ordinary carpenter's brace. These drills are adapted for boring either wood or metals, and are much more durable for rough work than are the regular wood-boring bits. Twist drills for use in a brace are especially desirable in the smaller sizes. The cost of these drills is from 10 cents upward, according to size and quality.

Hack saw.—Under ordinary circumstances a bar or rod of iron can be cut evenly enough with a hammer and cold chisel, but where exactness is required a hack saw (fig. 16) will be found desirable. As the little blades for cutting iron are very hard and brittle, it is necessary to set them firmly in the frame in order that there can be no chance of bending or buckling. In sawing iron, proceed as in sawing wood, except that slight pressure should be applied in the cutting direction only. The hack saw should be held firmly with both hands and a uniform movement of about 60 strokes a minute maintained. When the blade becomes worn or broken it may be replaced by a new one. The blades cost 8 to 10 cents each, and extra ones should be kept constantly on hand.

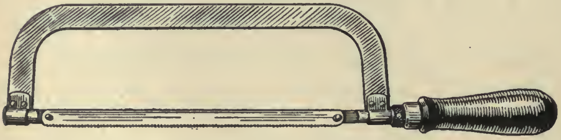

FIG. 16.—Hack saw. The thread for tightening the blade is located in the handle.

Soldering irons.—For general purposes a 1¼-pound soldering iron will be found satisfactory. Where continuous work is to be performed two irons are necessary, in order that one may be heating while the other is in use. Soldering irons should be heated only in a clear charcoal fire or in a blue flame of gas, gasoline, or alcohol. Before using a soldering iron it is essential that the tapering copper point be filed or ground until bright, and then coated with solder by first dipping the brightened hot point into a little of the soldering acid and afterwards rubbing over the solder. This process is known as "tinning" the iron, and is necessary in order to make the solder adhere to the copper and spread evenly. The iron must be retinned as often as the coating burns off. Soldering irons are sold by the pound, the price depending upon the market price of copper; however, the ruling price is about 40 cents a pound.

Thread-cutting appliances.—A set of stocks, dies, and taps for cutting threads on bolts and inside of nuts is quite desirable. This combination is termed a "screw plate" (fig. 17) and ordinarily includes all sizes from one-fourth inch to 1 inch. The prices of these tools vary according to make and number of pieces in the set, but a very good outfit can be secured for $8 or $10.

A cheaper device, known as a blacksmith's stock and dies, may be secured for $2.50 or $3, but is not as satisfactory as the regular screw plate. In selecting a thread-cutting outfit care should be taken that the pitch of thread corresponds to that used on standard bolts and nuts.

Pipe-fitting appliances.—With improved water-supply and plumbing fixtures it is possible for farmhouses and adjacent buildings to be equipped with modern conveniences. The work of installing the plumbing fixtures can all be done by the aid of a set of tools adapted to handling pipe and fittings. A set of pipe-fitting tools is essential to the employment of pipes in the installation of modern sanitary fixtures in dairy barns. A complete outfit for cutting, threading, and working pipe in sizes varying from one-fourth to 1 inch will cost about $10 for the simpler kinds of tools, and these answer every requirement. This outfit would include stocks and dies, a pipe cutter, a pipe vise, and two wrenches. It should be borne in mind that in stating the sizes of pipes the inside, instead of the outside, diameter is given. The thread used on piping is different from that employed on bolts; consequently the dies for one are not adapted to threading the other.

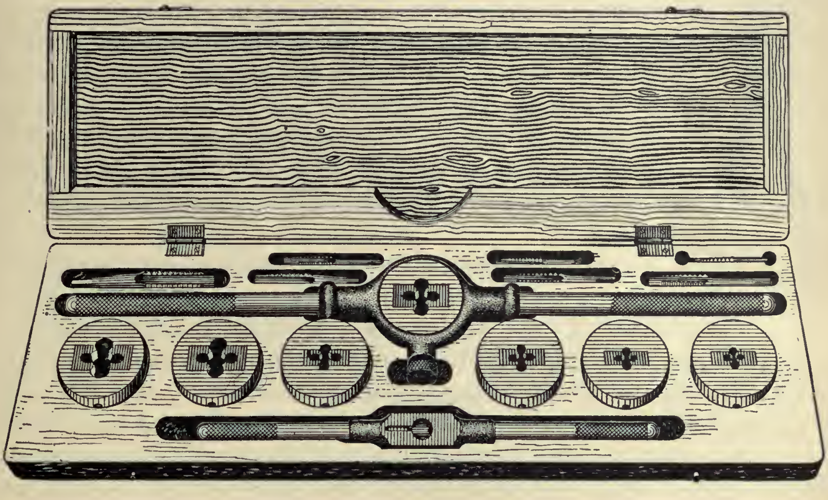

Fig. 17.—Screw plate.

MISCELLANEOUS TOOLS.

There are a number of tools adapted to the handling of both wood and metals required in general repair work about the farm.

Tinners' snips.—A small pair of tinners' snips, or shears, is desirable for cutting all kinds of sheet metals that may be required either for repair or construction work. The size of these shears is determined by the length of their jaws in inches. A 2½ or 3 inch size is desirable and should cost between $1 and $1.50.

Small vise.—A small bench or table vise having about a 2½-inch jaw is useful for many purposes, especially where the objects to be held are quite small. This tool is also desirable for mending harness in case a regular harness clamp is not available. A vise of this character will cost all the way from 50 cents to $1.50, according to size and quality.

Dividers.—The little implement known as dividers, or compasses, is desirable for drawing circles or segments of circles in the making of special parts of machinery from wood. The cost of a pair of dividers with a segment and set screw for setting to any angle should not be more than 60 cents.

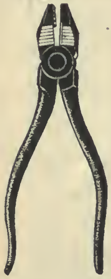
FIG. 18.—Pliers.

Pliers.—Some form of pliers for working wire is essential. Besides their use for handling wire a good pair of pliers is desirable for a great many lines of repair work. There are a number of styles of pliers on the market, but one of the simpler types (fig. 18) will give the greatest amount of service. As a rule a very serviceable pair of pliers can be secured for about 60 cents.

Cutting nippers.—A pair of heavy cutting nippers with circular jaws is useful for many purposes, especially for removing a shoe from the foot of a horse or for trimming the edge of a broken hoof. Where a horseshoeing outfit is maintained, the cutting nippers will be included.

Crowbar or pinch bar.—A crowbar or pinch bar will be found useful on the farm for prying or moving heavy objects. Where stones are to be removed from the soil a bar of this character is almost indispensable. A bar for general purposes weighing about 20 pounds will cost from $1 to $1.50.

Maul, or beetle.—A maul, or beetle, can be hewn from a gnarly piece of hickory or gum. The head portion of the maul should be about 9 inches in length and 6 or 7 inches in diameter. Through the middle of this block a hole about 1½ inches in diameter is bored and a shaved hickory handle inserted, forming a mallet weighing 16 to 25 pounds. If extra-heavy work is to be done, the head can be reenforced by means of iron rings, which are put on while hot and shrunken into place. This tool is desirable for driving heavy stakes and similar work.

Grindstone.—The farm repair outfit will not be complete unless some form of grindstone is included. The old type of stone with its wooden shaft, crank, and bearings has largely been replaced by the light-running treadle grindstones. No part of the repair work is so important as the keeping of tools in good order, and proper facilities for sharpening are essential. A good stone, mounted ready for use, will cost about $3.50.

Oilstone.—The oilstone is a necessary adjunct to the grindstone, its use being to put a smooth edge on the tools after grinding. Chisels, the bits of planes, and similar tools require grinding only occasionally, but may be sharpened quite frequently on the oilstone, and a fine cutting edge maintained. Instead of water, use kerosene or any light oil on the oilstone and wipe off clean when through sharpening. Oilstones can be bought at prices from 60 cents to $1.

Oiler, or squirt can.—This device is a convenience about the shop, both for oiling machinery and for keeping tools in order. A small oiler is desirable for use in connection with the oilstone. A can of this character will cost from 10 to 40 cents according to quality. In purchasing an oiler care should be taken to secure one having a folded seam where the bottom is joined to the main portion, as a soldered seam is liable to give out in a short while. It is also essential that the bottom should have plenty of "spring" to force the oil from the spout.

Wire stretcher.—On farms where wire fencing is employed it will be necessary to provide an appliance for stretching lines of wire. For light work, where short runs of single wire are to be handled, one of the hand-lever stretchers will be found most satisfactory. This tool consists of a wood lever about three feet in length, about one-third the distance from one end of which is attached a pair of grips or pliers to hold the wire. The wire is gripped in the holder, the short end of the lever passed around the post, and the power applied to the handle. A stretcher of this type can be purchased for about 75 cents.

Another form of stretcher consists of a wire grip to which is attached a ring through which an ordinary crowbar may be passed to serve as a lever. This type of grip is obtainable for about 50 cents.

Staple puller.—A staple puller is essential to the repair or alteration of wire fencing. An old mower guard will serve for this purpose, but a more satisfactory device may be constructed from a piece of $\frac{3}{4}$-inch steel rod, about 15 inches in length, by drawing one end to a point, then turning about $1\frac{1}{2}$ inches of this point at a right angle to the main portion. In using this tool the point is driven behind the staple by means of a hammer, then by a prying movement the staple is easily drawn. The handle end of the clawbar (fig. 4) may be shaped for use in drawing staples.

HARNESS-REPAIR OUTFIT.

The tools and facilities required for keeping harness in repair are comparatively simple and inexpensive. Many of the parts of harness, together with convenient supplies with which to make repairs, are now offered at reasonable prices by dealers everywhere. A considerable portion of the repair work on harness can be performed by the aid of tools required for other purposes, but there are a few special devices that are desirable.

Leather punch.—A good leather punch is one of the most desirable implements both for repair work and for making alterations in harness to fit animals of different sizes. A leather punch made somewhat on the order of a pair of pliers and having four or more punching tubes of various sizes is most desirable. It can be secured for about 40 cents.

Rivet set.—A rivet set is especially desirable for use in connection with solid copper or coppered steel rivets. This (fig. 19) is made of a small piece of tool steel and is provided with a small hole for driving down the washer on the rivet, also a countersink for expanding the end of the rivet.

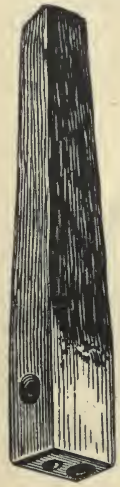

FIG. 19.—Rivet set.

Riveting machines.—There are upon the market several kinds of lever devices for use in the insertion of hollow or tubular rivets in leather. These riveting machines are comparatively cheap, but as a rule the hollow rivets do not hold so well as the solid rivets.

Awls.—For the repair of driving harness there should be kept on hand one or two awls to be used in making the holes for sewing with a waxed thread. Awls of this character can be purchased for about 10 cents each, including handle.

Harness clamp.—A clamp of some character is desirable for holding parts of harness while repairs are being made upon them. For this purpose a small table vise may be employed or a regular steel or wooden clamp may be purchased. A very serviceable homemade clamp may be constructed from two pieces of wood shaped somewhat like the staves of a barrel; at one end these pieces are dressed off so that they will fit together like the jaws of a vise, and the opposite ends may be hinged together or they may be fastened firmly to the sides of a base block. A short distance from the clamping end a screw, a bolt, a leather strap, or some other simple device may be used to draw the jaws tightly together.

SPECIAL CONVENIENCES.

In addition to the outfit of tools obtainable from a hardware dealer, there are a number of special devices that may be made on the farm and which will prove of great assistance in general repair work. Among the more important are the following:

Workbench.—A workbench of some kind will probably be the first essential. A good type of workbench is shown in the foreground of figure 21; also in cross section in figure 20. For the construction of this bench there will be required four boards seven-eighths inch thick, 12 to 14 inches wide, and about 12 feet in length. The length of the bench, however, will depend upon the size of the shop or other space that may be available for use as a workroom. Two pieces of 2 by 4 inch scantling, each 16 feet long, will be sufficient to construct the framework of the bench. All lumber entering into the construction of the workbench should be thoroughly seasoned and dressed to uniform width and thickness.

A clamp for holding materials should be constructed from a piece of hard wood and attached by the aid of a carpenter's bench screw, as shown in cross section in figure 20. This clamp should be provided with notches or pin holes at the lower end, so that it can be set to hold materials of any thickness. Along the front of the bench, two or three holes should be provided, into which pins may be set for supporting boards or other materials that are too long to be held rigid by the clamp alone.

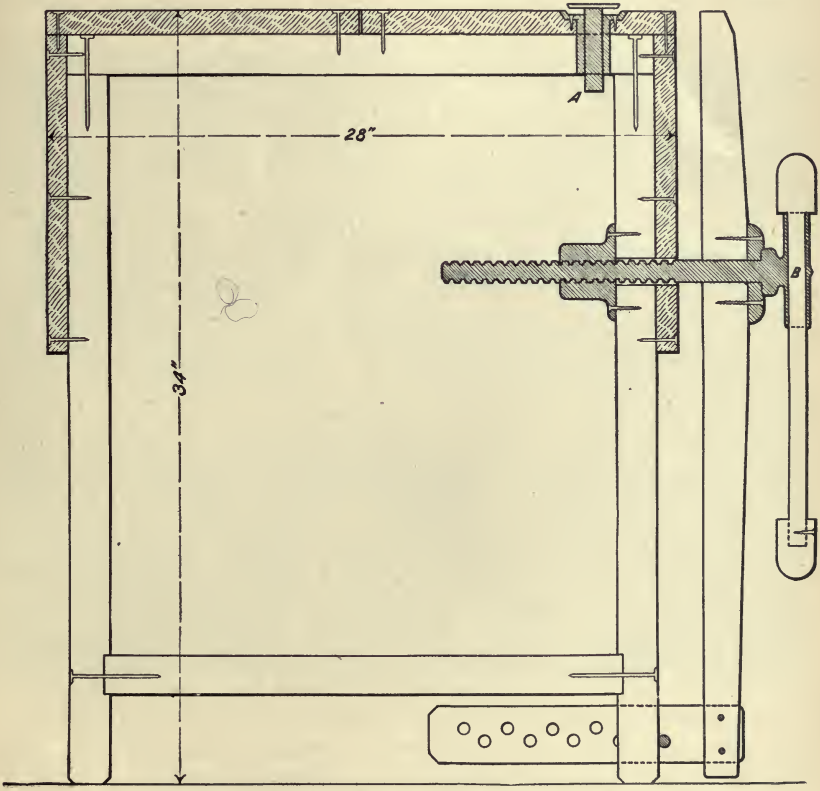

Fig. 20.—Cross section of workbench: *A*, planing stop; *B*, bench screw.

A "stop" for holding materials that are to be planed can be inserted in the top of the bench, near the left-hand end, as shown in figure 20. If a regular stop is not employed, its place may be taken by a small piece of notched board nailed on top of the bench.

Sawhorses.—A pair of trestles, or sawhorses, each consisting of a piece of 2 by 4 inch or 2 by 6 inch timber, about 4 feet in length, supported upon four legs, as illustrated in the foreground of figure 21, are very convenient for working upon while marking, sawing, boring, or chiseling. The sawhorses are an accessory to the workbench and should be constructed at the same time. The cost of materials with which to construct both the workbench and sawhorses should not exceed $5.

Miter box.—Among the accessories to the workbench there is perhaps no device that will give greater satisfaction than a good miter box to be used for sawing small wood materials either square or at an angle. For the construction of a miter box, three pieces of board 1 inch thick, 6 inches wide, and 3 feet in length should be selected and nailed together in the form of a square trough, taking care that the nails are driven well out toward the edge of the boards. Vertical cuts are sawed down through the sides to the bottom board to guide the saw when the box is in use. Near one end a cut is made at right angles with the length of the box to be used in making square cuts. For making bevel cuts for a right-angled miter joint, the sides of the box should be sawed down on oblique lines running at an angle of 45 degrees with the length of the box. Two such cuts should be made and should cross each other at the middle of the box, forming a letter X. In marking the box to make these cuts, the square should be laid flat on top of the box so that its corner is flush with the outer edge on one side, and each arm reaching obliquely across the box will show exactly the same number of inches to the outer edge on the other side. When the square has been correctly placed, mark along one arm for one of the cuts; then reverse the position of the square and mark for the other cut. A miter box is shown on top of the workbench in figure 21.

COMBINATION TOOL OUTFITS.

For the benefit of those contemplating the purchase of tools for use on the farm the following combinations are suggested. In making up these lists of general-purpose repair tools the better grades have been placed in the higher priced sets, although those included in the cheaper outfits should be of good and durable material.

A $2.50 outfit.—A hatchet, a handsaw, a small square, a screw-driver, and a pair of pliers.

A $5 outfit.—A hatchet, a 26-inch handsaw, a small steel square, a drawing knife, a brace and four bits (¼, ½, ¾, and 1 inch), a pair of pliers, a screw-driver, a cold chisel, a flat file, and a monkey wrench.

A $10 outfit.—A hatchet, a hand ax, a 26-inch handsaw, a 24-inch steel square, a drawing knife, a brace and six bits (¼, ⅜, ½, ⅝, ¾, and 1 inch), a pair of pliers, a screw-driver, a cold chisel, a 12-inch flat file, a monkey wrench, a jack plane, 2 chisels (½ and 1 inch), a rivet punch, a riveting hammer, a leather punch, and a small oil can.

**A $15 outfit.**—An ax with handle, a hand ax, a hatchet, a 26-inch handsaw, a 24-inch steel square, a drawing knife, a brace and six bits ($\frac{1}{4}$, $\frac{3}{8}$, $\frac{1}{2}$, $\frac{5}{8}$, $\frac{3}{4}$, and 1 inch), 3 twist drills ($\frac{3}{16}$, $\frac{1}{4}$, and $\frac{3}{8}$ inch, with square shank to fit in carpenter's brace), a bit gimlet, a screw-driver, a jack plane, a pair of pliers, 2 chisels ($\frac{1}{2}$ and 1 inch), an auger ($1\frac{1}{2}$ inch, with handle), a small vise, a cold chisel, a monkey wrench, a rivet punch, a claw hammer, a riveting hammer, a leather punch, a compass saw, a spirit level, an oil can, a 12-inch flat file, a 12-inch wood rasp, 2 small three-cornered files, a 2-foot folding rule, a chalk line, and a ball of chalk.

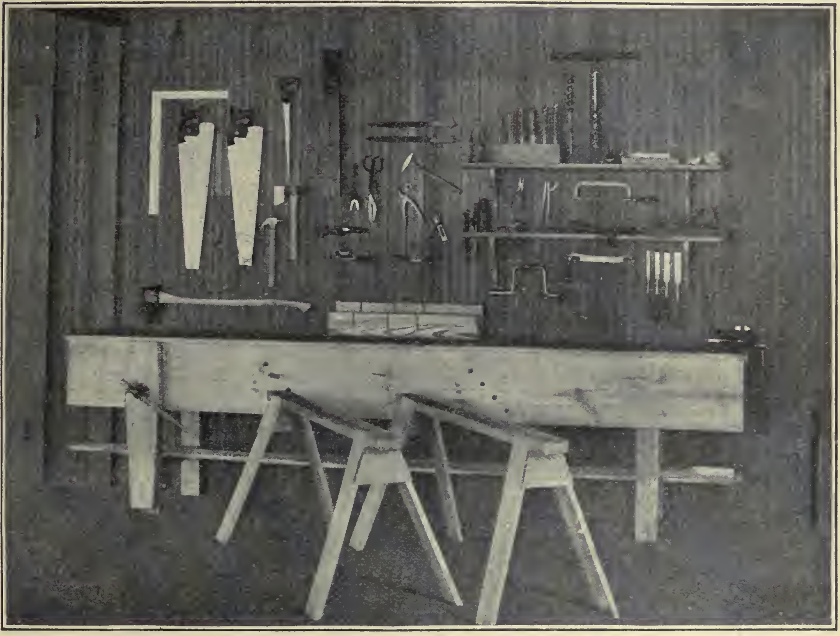

FIG. 21.—Interior of workshop with $25 outfit of tools, a workbench, sawhorses, and miter box.

A $20 outfit.—To the list given for the $15 outfit, add the following: A 26-inch ripping saw, a spokeshave, a bevel square, a scratch gauge, a pair of dividers, a small try-square, a scratch awl, 2 twist drills ($\frac{1}{2}$ and $\frac{5}{8}$ inch), an oilstone, and a pair of soldering irons.

A $25 outfit.—To the list given for the $20 outfit add the following: A small steel square, an alligator wrench, a hack saw, a 10-inch pipe wrench, a pair of tinners' shears, a ratchet brace instead of a plain brace, a rivet set, additional bits to make a full set of 12 ($\frac{1}{4}$ inch to $1\frac{1}{4}$ inches by eighths and sixteenths), and a smoothing plane. A $25 outfit is shown in figure 21.

IRON-WORKING AND SHOP EQUIPMENT.

Blacksmithing tools.—A blacksmith's outfit adapted to the requirements of a large farm should include a forge, an anvil, a 2-pound hammer, an 8-pound sledge, a riveting hammer, two pairs of tongs, an assortment of punches, hot and cold chisels, anvil hardie, cutting nippers, coarse files, screw plate, vise, drill press with drills, and a monkey wrench. The cost of this outfit may be as low as $30 or as high as $60 and upward, according to the class of materials selected. "Combination outfits" consisting of the above tools are offered at these prices, but if the outfit is made up by selecting from the general stock of a dealer, the price paid will be much greater.

Shop equipment.—The complete equipment of a shop for the making of general farm repairs should include the above blacksmithing outfit, the $25 collection of wood-working and general-purpose tools, a pipe-working combination, miscellaneous tools, harness-repair outfit, a workbench, a pair of sawhorses, and a grindstone. This entire equipment for a shop can be secured for about $100 in a fair quality of goods, and for $150 tools of excellent quality can be obtained.

SHOP FACILITIES FOR REPAIR WORK.

A shop or other suitable place where repair work can be carried on during cold or stormy weather is almost as important as the tools and materials with which to make the repairs. A small building devoted exclusively to shop purposes is desirable, but where this is not available a portion of one of the regular farm buildings may be utilized. One side of a wagon shed can frequently be devoted to this purpose. A workbench can be fitted up and provision made for the care of tools and supplies.

Plan of workshop.—A shop which meets the requirements of the general farm is illustrated by the floor plan shown in figure 22. The shop from which this plan was taken consists of a one-story building about 24 feet in length and 16 feet in width, having a plank floor over about two-thirds of its area, the remainder with an earth floor being used as a blacksmith shop. The floored portion was provided on the one side with a wood-working bench, over which were placed several shelves for the reception of tools. On the opposite side there was provided a heavy plank bench with a vise and other equipment for working iron. Below the iron-working bench there should be provided a rack upon which to store the stock of various sizes of square and round iron required for making repairs. Above the iron-working bench there should be a few shelves for the storage of tools; also numerous pigeonhole boxes for the accommodation of the stock of bolts, nuts, and washers.

This shop was constructed of cheap lumber, the siding being put on up and down with cracks battened, and it has a simple gable roof. By this type of construction ample space is secured overhead for the storage of materials, especially seasoned timber for use in making repairs. An abundance of light is essential to good work, and as much of the repair work will be done during dark and cloudy weather, the windows should be numerous and so distributed as to provide for uniform lighting. The windows should be protected on the inside by wire netting.

The large doors in the end of the shop are made to cover the entire space between the workbenches, so that the larger farm implements may be brought upon the floor for repairing. Where the climate is cold, provision should be made for a heating stove, in order that the shop may be comfortable for work during winter weather.

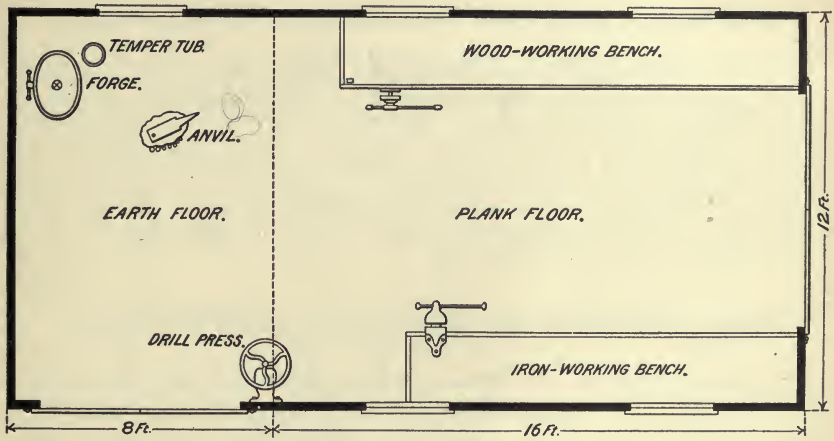

FIG. 22.—Floor plan of workshop.

If a portion of a wagon shed or other farm building is set aside for shop work, it should, so far as practicable, be fitted up the same as a regular shop.

The care of tools.—The system of storing the tools should conform to the needs of those using them and to the work to be performed. In many instances it may be desirable to keep the tools in a portable chest in which they may be carried to any part of the farm or plantation; on the other hand, if the work is done almost entirely at the shop the tools will be more accessible when supported on the walls or upon shelves above the bench.

In climates where the atmosphere is moist the greater part of the time, it is not wise to keep the tools exposed by hanging them on the walls or laying them upon open shelves, but a wall cabinet or a tool chest should be provided. It should be the aim to have a place for every tool, and then cultivate the practice of returning it to its proper place immediately upon the completion of the work in hand. A very good plan for keeping the tools in their respective places is to first draw an outline of each tool in its place upon the wall and then paint this space black or some color in contrast with the wall itself, so that when any tool is not in its place its absence will be readily apparent.

Many persons are in the habit of leaving tools where they finish using them. In the first place, a tool can not be kept in working condition if allowed to remain exposed to the weather, and in the second place the time lost in locating the tool when it is next required for use will be much greater than that which would be required to return it to the proper place.

MATERIALS REQUIRED FOR GENERAL REPAIR WORK.

However complete the tool equipment, it will be of little use without a supply of materials with which to replace worn or broken parts of machinery and implements. The time required to secure stock materials may be as great as that necessary to have the repairs made in the nearest shop. A supply of timber, bar iron, bolts, rivets, screws, etc., should be kept constantly on hand and renewed from time to time as the stock runs low.

WOOD MATERIALS FOR REPAIRING FARM EQUIPMENT.

The supply of wood for use in making repairs should be well seasoned and dry. It should include split hickory, ash, and oak, from which handles, singletrees, doubletrees, neck yokes, and similar articles can be made. Split timber is better than sawed for these purposes, owing to the straight grain when the wood is split. Sawed oak, ash, or heart pine, in sizes 1 by 2, 2 by 4, 2 by 6, 3 by 4, 3 by 6, 4 by 4, and 4 by 6 inches, and 14 or 16 feet in length is frequently required for use in replacing broken handles, braces, tongues, axles, etc. It is also desirable to have on hand a small stock of white pine, one-half and seven-eighths inch in thickness, for use in repairing or replacing the lighter wood parts of implements.

A great variety of wooden parts for farm implements is kept in hardware and general supply houses. On large farms it is advisable to keep on hand one or two each of the following: Ax handles, hatchet and hammer handles, hoe and rake handles, fork handles, shovel handles, singletrees and doubletrees, wagon tongues, carriage poles, and buggy and wagon shafts.

It should be the practice to save every small piece of good material and store it in a dry loft or other convenient place. A good piece of a thin board can frequently be saved from a broken packing box, and this will serve as well as new material for repair work. It should be the policy to save every good barrel hoop or extra barrel head for future use in replacing a broken or missing one. Very little time will be required to care for these articles if some system of storing them is employed.

METAL MATERIALS FOR REPAIRING FARM EQUIPMENT.

Bar Iron.

Where a regular blacksmith outfit is maintained the supplies kept on hand should include a stock of both round and square iron. The bars come in lengths of about 14 feet.

Round iron bars.—The stock should include the following: ¼, ⅜, ½, ⅝, and ¾ inch, three to five bars each, and one bar 1 inch in diameter. The ⅜ and ½ inch sizes are most frequently needed.

Rectangular iron bars.—The stock should include the following sizes: ⅛ by ¾ inch, ⅛ by 1, ¼ by 1, ¼ by 2, ⅜ by 1, ⅜ by 1½, ⅜ by 2, ½ by 1, ½ by 1½, ½ by 2, and ½ by 3 inches. The greatest demand will be for ¼ by 1 inch, ¼ by 2, ⅜ by 1½, and ½ by 2 inches, and of these sizes three or four bars should be secured. Of the other sizes one or two bars will usually suffice.

T-bars and angle iron.—These in sizes up to 2½ inches are very useful for making repairs on harrows, cultivators, and other implements in the construction of which such iron has been used.

The price of bar iron varies with the market, but it is usually less than $3 per hundredweight.

Iron Bolts.

For the convenience of intending purchasers, a list of bolts is given. The sizes most needed in repair work are indicated by the larger numbers suggested. For information concerning prices, dealers or their catalogues should be consulted, as the prices vary with locality and market conditions. Bolts, screws, and rivets can be secured at a great reduction if purchased in original packages containing 50 or 100, or a gross, as the case may be.

Carriage bolts.—As a rule the round-headed or carriage type of bolt is best adapted for use in wood or where wood and iron are bolted together. Whenever a nut is being drawn down upon wood, a washer should be placed beneath it. A hole bored for the insertion of a carriage bolt should not be more than one-sixteenth inch larger than the bolt, as the square shank of the bolt should be driven solidly into the wood to prevent its turning. The difference between machine and carriage bolts is shown in figure 23.

The supply of carriage bolts should include the following: 100 each of ¼ by 2, ¼ by 3, and ¼ by 4 inches; ⅜ by 2, ⅜ by 3, ⅜ by 4, and ⅜ by 6 inches; ½ by 1½, ½ by 2, ½ by 4, and ½ by 6. Of the following sizes a dozen each should be secured: ½ by 8, ½ by 10, and ½ by 12 inches.

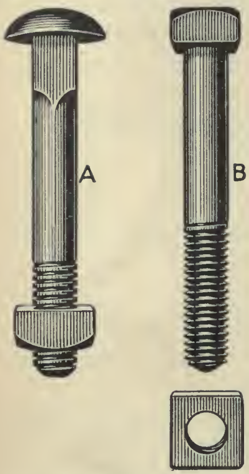

FIG. 23.—Bolts: *A*, carriage bolt; *B*, machine bolt.

Machine bolts.—These have square heads but the shanks are round throughout. For bolting together iron parts, they should always be used. The following will make a fair supply for a farm: 100 each of ⅜ by 2 and ⅜ by 4 inches; ½ by 1½, ½ by 2, ½ by 3, ½ by 4, and ½ by 6 inches; ⅝ by 2 and ⅝ by 4 inches. A dozen each of the following should be included: ½ by 8 and ½ by 10 inches; ⅝ by 6, ⅝ by 8, and ⅝ by 10 inches; ¾ by 3, ¾ by 4, ¾ by 5, ¾ by 6, ¾ by 8, ¾ by 10, ¾ by 12, and ¾ by 14 inches.

Tire bolts.—Bolts either 3/16 or ¼ inch in diameter and from 1½ to 2 inches in length are most used. Examine the wheels of the vehicles which are to be kept in repair, and get two or three dozen of each size of bolts needed. A few felly plates should be included.

Extra nuts.—To replace lost nuts, the following should be included in the stock: 25 each of ¼, ⅜, ½, ⅝, and ¾ inch sizes.

Washers.—For use with bolts and rivets, get 2 pounds each of the ¼ and ⅜ inch sizes, and 5 pounds each of the ½ and ¾ inch sizes.

Rivets, Screws, Nails, Etc.

Iron rivets.—For most purposes rivets with small round heads or with broader flat heads are used. The sizes most needed are 3/16 and ¼ inch in diameter and ¼, ⅜, ½, ¾, and 1 inch in length. From a half pound to a pound of each size will be an ample supply. Rivets with countersunk heads are used for some purposes, and a few of the different sizes should be secured; also a few of the special rivets used in repairing mower and reaper knives.

Wood screws.—Screws are classified by number and length, the number referring to the diameter. They are put up in boxes each containing one gross. A gross each of the following sizes should cost about $2, and will meet all ordinary demands: No. 6, of ¾ and 1 inch lengths; No. 8, of 1, 1¼, and 1½ inch lengths; No. 10, of 1¼, 1½, 1¾, and 2 inch lengths; and No. 12, of 2 and 2½ inch lengths.

Nails.—Of flat-head wire nails, 5 pounds each of 3, 4, 5, and 6 penny sizes and one keg (100 pounds) each of 8, 10, 20, and 40 penny sizes should be obtained. Nails purchased in small quantities will cost 4 and 5 cents a pound, but if secured by the keg the cost is generally below 3 cents a pound. For certain purposes, such as the laying of floors and the construction of partitions from matched lumber, the square cut steel nails are considered desirable. Wire brads of various sizes and lengths are useful for both repair and construction work, and a few of these of different sizes should be secured.

Staples.—Of the standard size used in the construction and repair of wire fencing, 10 pounds or more should be kept on hand; also a pound or two of the smaller sizes for fastening poultry netting. Small staples, known as "double-pointed tacks," are useful for tacking fly screen over windows and for many other purposes.

Strap hinges, clips, wire, tin, etc.—On farms that are at a distance from a hardware store, a few pairs of strap hinges of 3, 4, 6, 8, 10, and 12 inch lengths should be kept in stock. Hooks and staples or iron latches for fastening gates and barn doors may also be included in the hardware list. Clips for singletrees, doubletrees, and neck yokes are offered by dealers at prices far below the cost of having them made at a local shop. Other materials that may often prove useful are small copper wire, annealed wire, galvanized wire, hoop iron, galvanized sheet iron, and sheet tin.

SUPPLIES FOR REPAIR OF HARNESS, CARRIAGE TOPS, ETC.

Every farmer should have on hand supplies for the repair of harness, and many will find it an advantage to have also some materials for making the simpler repairs on carriage and buggy tops. Ready-made harness and bridle parts of all kinds can be secured from many of the larger establishments.

Harness rivets.—The solid rivets for harness repairs are either of copper or coppered steel, the former costing about three times as much as the latter. They can be bought in boxes containing assorted lengths ranging from one-fourth to three-fourths inch.

Leather.—By visiting a regular harness shop, it is often possible to secure at a small cost scraps of harness leather that will prove very useful in making repairs; but where the amount of repairing to be done is large, the purchase of a whole side of good harness leather is advisable.

Harness hardware.—The supplies of this class most often required are buckles of various sizes, snap hooks, bridle bits, hame staples, hame clips, cockeyes, open links, and rings of different sizes.

Other materials.—The outfit should also include thread, beeswax, extra awls and needles, carriage washers, knobs and eyelets for carriage curtains, shaft tips, and harness oil. A broken shaft may often be made good with a metallic shaft end. There are also on the market a number of devices, known as "menders," for making quick temporary repairs to harness.

PAINTS, OILS, AND MISCELLANEOUS SUPPLIES.

For repainting the farm equipment the following supplies will be found useful: White lead, red lead, Venetian red, raw linseed oil, and turpentine. Ready-mixed paints can be used, but when made of good materials they are more expensive. For lubrication purposes there should be a supply of machine oil, axle grease, and castor oil. For miscellaneous purposes there will be required small quantities of liquid glue, rubber cement, solder, soldering fluid (prepared by adding metallic zinc to strong hydrochloric or muriatic acid), sandpaper, emery cloth, and twine.

SUGGESTIONS.

The lists contained in this bulletin include many things that will not be required on a large number of farms. Where specialized farming is pursued, only the tools and supplies with which to repair the special farm equipment will be required. The indiscriminate purchase of tools may result in direct loss.

In deciding what tools and materials to purchase, always give preference to those most frequently and urgently needed, passing over those that will be rarely used.

Keeping a machine or vehicle in good repair and well oiled not only increases its efficiency, but lessens the power required in using it.

The proper maintenance of farm machines not only saves money but avoids danger to those who operate them. Keeping the harness and vehicles in repair may prevent a dangerous runaway.

So far as practicable let the repair work be done when regular farm work is not pressing, as on rainy days and during the winter season. Pursue the repair work as a kind of recreation or rest from the regular farm operations.

Do not have several places for the storage of repair tools and supplies. Have one convenient place, and see that all tools are kept there when not in use.

Tools and materials should be kept in their proper places. Do not keep all sizes of bolts or screws mixed together in a single receptacle, but fit up suitable boxes or bins, so that the supplies may be accessible on short notice.

Keep all tools clean and free from rust, and all edge tools sharp.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 348.

BACTERIA IN MILK.

BY

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WASHINGTON:
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1909.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Animal Industry,
Washington, D. C., December 5, 1908.

Sir: I have the honor to recommend that the accompanying paper on "Bacteria in Milk," by L. A. Rogers, of the Dairy Division of this Bureau, be published as a Farmers' Bulletin. This paper appeared in the Yearbook of the Department for 1907, but owing to the demand for information such as it contains and to the widespread interest in the subject of wholesome milk I consider it desirable that it should be issued in the Farmers' Bulletin series.

Respectfully,

A. D. Melvin,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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BACTERIA IN MILK.

MILK—ITS COMPOSITION AND CHARACTERISTICS.

A study of the changes produced in milk by bacteria is a study of the decomposition of the constituents of milk. Many of these changes are so complex that they can not be discussed in a paper of this nature. The fats are usually little affected by the growth of bacteria in milk. The sugar, on the other hand, is frequently fermented, and various acids, gases, and alcohol may result. The casein and the albumen are decomposed by many bacteria. The products of the decomposition sometimes have sharp or disagreeable flavors and not infrequently unpleasant odors.

It has been shown that milk contains certain digestive principles—the so-called unorganized ferments, or more properly enzymes—which slowly digest the milk. Fresh milk, collected and held without bacterial contamination, will spoil in time unless these enzymes are destroyed by heating.

BACTERIA—THEIR NATURE.

To understand the changes that take place in milk it is necessary to consider briefly the nature of the minute organisms causing these changes.

The basis of all life is the mysterious jelly-like substance to which scientists have give the name of protoplasm. In its various forms it constitutes the actual living, changing part of every living thing, plant or animal. The simplest living things are merely shapeless, naked masses of this protoplasmic jelly. Bacteria show the first differentiation toward the complete plants with which we are familiar. The protoplasm is covered and held in definite shape by a very thin and delicate wall. They are then tiny one-celled plants. The plants growing in our gardens are made up of an infinite number of cells, organized like the workers in a community, each kind doing a particular work and all necessary to the complete plant. In bacteria, however, each cell is a complete plant in itself. (See figs. 1–4.) Their food must be in a condition to pass through the cell wall to the living protoplasm within. It must be in solution in water and it must be diffusible—that is, it must be a substance that will pass through a membrane, otherwise it could not pass through the cell wall of the plant. Not all substances soluble in water will pass through a membrane. Thus albumen, while soluble, can not, as will be pointed out later, be used by bacteria until it has been changed.

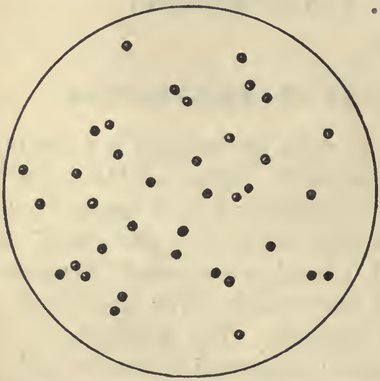

FIG. 1.—Bacteria of the spherical or coccus type.

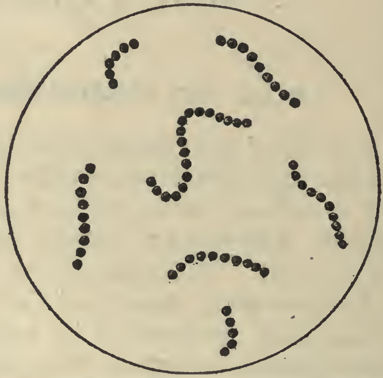

FIG. 2.—Bacteria of the coccus type hanging together in chains.

On the other hand, sugar is both soluble and diffusible and probably can be used for food by bacteria without previous change.

Through infinite generations of dependent existence bacteria have lost their ability to live independently and have become parasites or saprophytes. In other words, they are no longer able to elaborate their nourishment from the simpler compounds existing in the air and the earth, but must depend on higher, better organized plants or animals to prepare their food for them. Hence we find them living only where there are present at least traces of animal or plant tissue. If they depend on living tissue, they are called parasites; if they

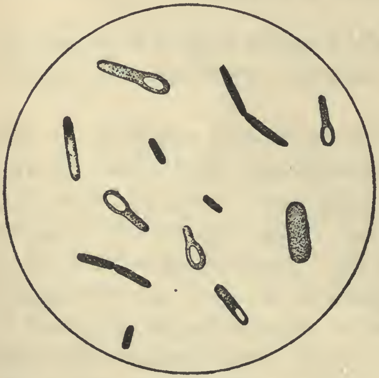

FIG. 3.—Typical rod-shaped bacteria (Baccillus type). In some of these spores are shown as clear areas.

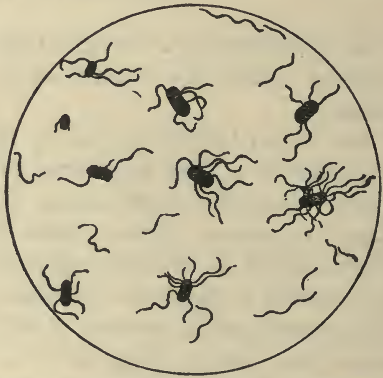

FIG. 4.—Bacteria with hair-like appendages which enable them to swim about in water or milk.

obtain their nourishment from dead, partly decomposed plant or animal matter, they are known as saprophytes.

The growing corn plant is so delicate that it is killed by a short exposure to a freezing temperature or to a scorching sun; yet the dried corn kernel will stand the most intense cold, long drying, or comparatively high heat, and when proper conditions are provided will grow. In a somewhat similar way some bacteria are provided with means of withstanding unfavorable conditions. These bacteria form a small round or oval body in the interior of the cell. When the bacterium dies, this spore, as it is called, is set free. Like the seeds of the higher plants, it is able to survive long drying and great extremes of temperature. To destroy spores by heat, it is necessary to expose them to long-continued boiling or for a short time to temperatures above the boiling point of water.

The bacteria are so small that it is difficult to form a conception of their dimensions. It is only when we consider them in the aggregate that they reach units of measure with which we are familiar. It is estimated that if 25,000 average-sized rod-shaped bacteria were placed end to end their combined length would equal 1 inch. The weight of an average bacillus is so small that it has been estimated it would take over 600,000,000,000 of them to equal 1 gram, or 16,800,000,000,000 to weigh 1 ounce.

What the bacteria lack in size is made up in their great numbers and powers of reproduction. A cubic centimeter of milk, which contains about 25 drops, frequently contains thousands, sometimes millions, even hundreds of millions, of bacteria. A single drop of sour milk may contain 40,000,000 bacteria.

Bacteria reproduce themselves by a very simple process, known as fission. The cell becomes elongated and a partition wall is formed across the middle. The two cells thus formed separate, and we have two bacteria. Higher plants may take weeks and months, or even many years, to grow to maturity. These simple plants known as bacteria, however, under favorable conditions may complete their growth and reproduce themselves in less than an hour.

Bacteria, in common with all other living things, obey certain fixed laws. Certain elements and certain combinations of elements are necessary for their growth. There seem sometimes to be exceptions to these laws, but closer study shows that these exceptions are only apparent.

It would be very easy for the layman to obtain the impression by reading popular descriptions that bacteria are peculiar and unusual plants, having little in common with other forms of plant life. On the contrary, bacteria, in their form, habits of growth, and life processes, closely resemble many other simple plants, like the algæ, the yeasts, and the molds.

RELATION OF TEMPERATURE TO GROWTH OF BACTERIA.

The relation of bacteria to temperature is most interesting and important. A certain amount of heat is essential and a certain amount is fatal. Each particular variety of bacteria has an upper and a lower temperature limit beyond which it does not grow and a certain temperature, called the optimum, at which it grows best.

Most forms occurring in milk find their optimum temperature between 80° and 98° F. Few bacteria grow at all above 100° and at 125° the weaker ones soon die. An exposure of ten minutes at 150° to 160° F. is fatal to nearly all bacteria which do not form spores. Spores, as previously mentioned, are destroyed only by prolonged boiling, exposure to steam under pressure, or to a high degree of dry heat. With dry heat, such as is obtained in an oven, much higher temperature and longer exposures are necessary to secure the same results. In the laboratory small flasks of milk are sterilized by holding them in a small steam boiler at a temperature of 248° F. for fifteen minutes. (See fig. 5.)

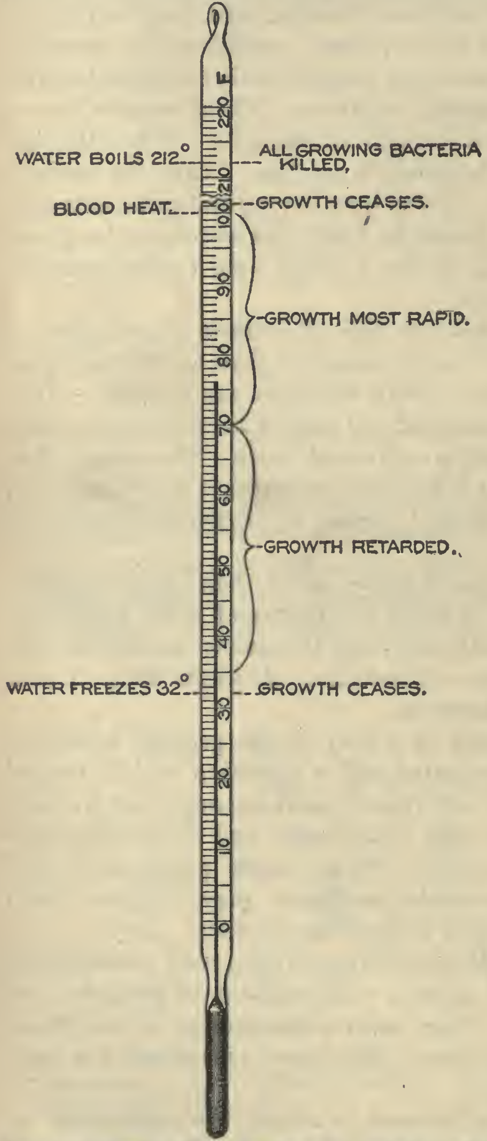

Fig. 5.—Influence of temperature on bacteria ordinarily found in milk.

If the milk is cooled and held at 50° F. or, better still, 40°, growth is checked at once and multiplication is very slow. One writer has represented the relative increase of bacteria in milk held at different temperatures as follows:

Multiplication of bacteria in milk held at different temperatures.

Milk held at—	Relative number of bacteria at the end of—				
	0 hour.	6 hours.	12 hours.	24 hours.	48 hours.
68° F	1	1.7	24.2	6,128.0	357,499.0
50° F	1	1.2	1.5	4.1	6.2

In the foregoing table, 1 is assumed to represent the number of bacteria in the fresh milk, and the relative numbers which will be found at the end of six, twelve, twenty-four, and forty-eight hours, at the two temperatures, are shown in the succeeding columns. These figures are based on a number of actual counts and illustrate the effect of a difference of 18° on the multiplication of bacteria. If the milk had contained at the beginning 1,000 bacteria, the part held at the lower temperature would have contained at the end of twenty-four hours only 4,100 bacteria, while the other would have contained at the same stage 6,128,000.

The temperature may have a decided influence on the kind of bacteria growing in milk as well as on the numbers. There is a constant struggle for existence among the various kinds of bacteria in the milk, and those which find the conditions most favorable or succeed in so changing the milk that it is more favorable or less unfavorable to them than to other kinds will gradually crowd the others out. If a sample of milk is divided into three parts and held at three different temperatures—as, for instance, 35°, 70°, and 98°—the bacteria predominating in each of these parts at the end of two or three days will probably be quite different. Thus we see how it is that milk may undergo so many changes. Even when milk is handled in the same way day after day there may be marked differences in its appearance or flavor. Changes in the conditions so slight that they may escape our notice may produce great variation in the final results. The amount and nature of the contamination must necessarily vary more or less from day to day. Even with the same contamination the temperature of the atmosphere may change the whole course of the fermentation.

SOURCES OF BACTERIA IN MILK.

It has been assumed by many writers that milk is formed in the udder entirely free from bacteria. This has frequently been disputed and is still a matter of some doubt. However, the best authorities agree that milk is bacteria-free when formed, unless the udder is so injured or diseased that there is a direct passageway from the blood vessels to the milk ducts. It should be remembered that an injury so slight that it would escape the most careful examination might be sufficient to allow the passage of bacteria.

Even if the milk is secreted bacteria-free, it is very difficult to obtain it perfectly sterile. Bacteria work their way into the milk cistern through the opening in the teat and find there conditions under which they can grow and multiply. This growth is ordinarily confined to the lower part of the udder, and the greater number of the bacteria are washed out with the first few streams of milk. Sometimes, however, the growth may extend into the smaller milk ducts, and the last part of the milk will contain nearly as many bacteria as the first.

Inflammation of the udder or fermentation of the milk in the udder rarely occurs, because there is only a very small amount of milk held in the udder, and most of the bacteria found there have little or no effect on milk. It is also true that fresh milk, like the blood, contains some substance which has an inhibiting influence on bacteria. This influence is so slight that it is probably of little practical importance, but it may have some relation to the comparatively slow development of bacteria in the udder.

The real contamination occurs after the milk has left the udder. In spite of careful milking, dirt, particles of dust, hairs, even bits of manure from the flanks or udder of the cow, may fall into the milk. All of these things invariably carry more or less bacterial contamination. Manure usually contains large numbers of bacteria, many of them being kinds which produce very undesirable changes in milk; and the dry dust of the stable floor contains great numbers and varieties of bacteria. This dust soon settles, and an open milk pail catches a surprisingly large amount.

But the contamination does not end here. The pails or the cans may not be properly cleaned, and the corners or seams may hold small particles of dirt or sour milk. These impurities are full of bacteria, which quickly find their way into the milk. The cloth through which the milk is strained may not have been properly scalded, and the bacteria are not only not all destroyed, but have actually multiplied in the damp cloth. When the strainer is used again many of these bacteria are washed out by the milk.

If a cooler is used it may add to the contamination if it is placed so that it catches dust. Finally, the bottles in which the milk is distributed may not have been properly washed and steamed, and thus may become another source of contamination.

The contamination from each individual source may be small, but taken all together it has a serious influence on the quality of the milk. If extraordinary precautions are taken to prevent contamination, the number of bacteria in the fresh milk may be kept down to a few hundred per cubic centimeter; with careful milking it may easily be kept within a few thousand; with careless milking and handling the number will vary greatly with circumstances and may exceed 100,000.

The bacteria in milk from cows kept in stables may be different from the bacteria in milk from cows on pasture. Bacteria which occur rarely in milk during the winter months may become numerous in the summer, and specific fermentations which are almost unknown in the summer may appear in the autumn or winter.

It should not be assumed that all bacteria are harmful either to milk or to the human system. In fact, many kinds of bacteria will grow in milk for a long time without changing its taste or appearance, while many of the fermentations which make milk undesirable for direct consumption are used in making butter and various kinds of cheese. Very few of the bacteria cause disease or produce poisonous by-products.

FLAVORS IN MILK.

Milk may acquire abnormal flavors and odors in various ways:

(1) The cow may, through some pathological condition, produce milk with an unusual flavor. This may occur when the cow shows no outward sign of disorder and usually lasts for a short time only.

(2) Highly flavored foods may impart their peculiar flavors to the milk. The disagreeable results of feeding even small quantities of wild onion, turnips, and similar feeds are unfortunately too familiar to need comment. Other feeds with a less pungent taste no doubt affect the flavor of the milk to a less degree.

(3) Milk, especially warm milk, takes up the odors and flavors of the surrounding air with great rapidity. The flavor thus acquired may be so slight that it ordinarily passes unnoticed, or it may be so pronounced that anyone may recognize its source.

(4) The flavor of milk may be materially changed by the growth of bacteria, with the infinite variety of by-products which result from their development. If milk is sterilized and then inoculated with some one kind of bacteria, a certain flavor, frequently very pronounced, will result; and under the same conditions this particular variety will always produce the same flavor. Another kind may produce an equally pronounced but entirely different flavor, while some species may grow for a long time without causing any noticeable change. In ordinary milk, however, the conditions are different, in that many kinds of bacteria are growing together and the milk is usually consumed before there is any marked change in the flavor.

When a number of different kinds of bacteria grow together, as they usually do in milk, the development is not equal. One variety finds the conditions of food or temperature or acidity more suited to its peculiar habits of life and develops more rapidly than other kinds.

In a short time this rapidly growing form may so change the milk that, while the conditions are more favorable to its own growth, they become less and less adapted to the needs of the others. In the course of time this form crowds out all others and an examination would show large numbers of this kind, while the others originally present would have entirely disappeared or would occur only occasionally. It is in this way that the special fermentations develop.

If milk shows a peculiar flavor when it is first drawn, it is safe to say that the flavor is not produced by bacteria but by the cow, usually through something in the feed. If, on the other hand, the fresh milk is normal and the flavor develops as the milk stands, it is usually due to bacteria.

SOURING OF MILK.

Many of the lower plants find sugar a suitable food. In making use of this food, the sugar is chemically changed and in its place we find many new chemical compounds differing widely from the sugar from which they originated. Some bacteria in this process form various kinds of acids and gases. Among these is a large group of closely related bacteria which cause the souring of milk by breaking up the milk sugar into lactic acid. On account of this peculiarity they are commonly called the lactic-acid bacteria (fig. 6). Typical lactic-acid bacteria do not form gas. They do not have spores and therefore are destroyed at a comparatively low temperature. They are extremely widely distributed, and it is only under exceptional conditions that milk is obtained entirely free from them. They seldom or never occur in the udder itself, but probably are introduced into the milk with the hair, bits of feces, and dust that fall into the milk in the barn.

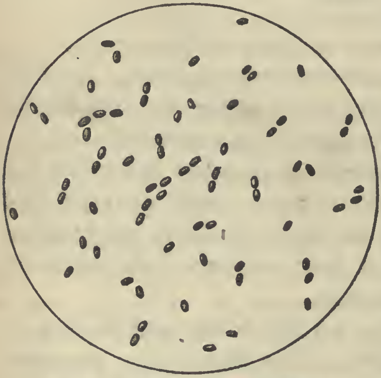

FIG. 6.—Typical lactic-acid bacteria.

Milk is an excellent medium for the growth of lactic-acid bacteria, and under favorable temperature conditions they multiply with astonishing rapidity.

The acidity of the milk is so closely connected with the life processes of this group of bacteria that it may be taken as a rough measure of their development. The acid, as fast as it is formed, unites chemically with the casein, which exists as very fine particles suspended in the milk serum. When the acid reaches a certain per cent, the acid casein is precipitated and the milk is said to have "curdled" or "clabbered." This result may be hastened by heating. If milk or cream that is slightly sour is added to hot coffee, or is otherwise heated, it curdles.

Milk which has undergone a strictly lactic-acid fermentation has a firm curd, free from gas bubbles and with a small amount of whey on the surface. When shaken the curd breaks up into small particles which settle slowly, leaving a clear whey. The milk should have a pleasant acid taste. So far as is known, none of the products of the bacteria of this group is of a poisonous nature.

Some of the bacteria commonly classed with the lactic-acid bacteria form acids other than lactic, together with large quantities of gas. Milk curdled by bacteria of this class shows gas bubbles and has a disagreeable taste.

The lactic-acid bacteria not only are able to grow in an acid medium, but to a certain point the acid is a favorable influence. Many bacteria, however, find the acid detrimental to their development and are not able to grow long in milk in competition with lactic-acid bacteria. When the milk begins to taste sour the growth of nearly all nonacid-forming bacteria is checked. The activity of the lactic-acid bacteria themselves is checked and finally ceases entirely when the acid reaches a certain concentration, which varies with different varieties. Consequently sour milk usually contains a nearly pure culture of one or at most two or three closely related varieties of bacteria.

While the lactic-acid bacteria are considered very beneficial in butter and cheese making, they are undesirable bacteria from the standpoint of the milk dealer or consumer. It is almost out of the question absolutely to prevent their presence in milk, but the initial number may be much reduced by observing a few simple rules of cleanliness in handling the milk. Every precaution which reduces the amount of dirt in milk reduces the number of bacteria correspondingly. The important factors here are freedom from dust at time of milking, brushing the cows, wiping the udders, and small-mouthed milk pails. It is also of great importance to cool the milk as soon as possible after milking to below the temperature at which lactic-acid bacteria grow rapidly. This temperature is controlled by practical conditions, such as the temperature of the water available for cooling, but it should not be higher than 50° F.

SWEET CURDLING AND DIGESTION.

It sometimes happens that milk curdles without showing the usual acid taste. This is followed by the separation of a straw-colored whey, which slowly increases until the curd has nearly all disappeared. This condition is the result of a series of complicated changes brought about by bacteria.

When milk is taken into the stomach, especially the stomachs of young animals whose diet is largely or wholly milk, a certain constituent of the digestive juice precipitates the casein, forming a firm curd. This curd resembles the acid curd in appearance, but differs from it chemically and has no sour taste. The part of the digestive juice which produces this change is the rennet, with which we are familiar in cheese making and in the junket tablets of the kitchen. It is what is technically known as an enzyme, and while it has some of the properties which we ordinarily attribute to living beings, its action is purely chemical.

In this precipitated condition the casein is not in a form to be used by the animal. It must be so changed that it will go into a solution and pass through the membranes lining the digestive tract. This change is brought about by another enzyme, pepsin. Pepsin changes the curd rapidly and completely into compounds soluble in water.

A process similar to these digestive processes in the stomach takes place in milk when it is subjected to the action of certain kinds of bacteria. The bacteria have no stomachs, but some of them have the ability to secrete enzymes somewhat like the rennet and the pepsin of animals. Thus the milk can or bottle becomes in a certain sense the communistic stomach of myriads of bacteria. From each cell is given out a trace of rennet and the digesting enzyme. These enzymes have the peculiar property of acting continuously without reduction of their power. Thus it happens that the milk is curdled in a few hours and the casein is slowly converted into products capable of passing through the delicate membrane surrounding the bacteria. The food thus produced is obviously far in excess of the needs of the bacteria.

A large group of bacteria, more or less closely related, produce changes of this nature. Some of them form by-products with disagreeable odors and tastes and some form gases. They are found normally in the soil, in water, in the filth of the stable, or the dust that floats in the air. They are invariably found in milk in greater or less numbers. They are ordinarily checked by the activities of the lactic-acid bacteria and become predominant only under special conditions. When, through careless handling, any exceptional number of bacteria of this class are introduced into the milk, they may bring about rennet curdling and digestion before they are suppressed by the acid produced by the lactic-acid bacteria.

Again, in hot weather the temperature of the milk may be so high that it is more favorable to the digesting bacteria than to the lactic-acid bacteria and the former gain the ascendency.

BITTER MILK.

The distinct bitter taste which sometimes appears in milk may be caused by (1) certain weeds that the cow has eaten, (2) an abnormal condition of the udder, (3) an advanced period of lactation, or (4) the action of certain bacteria. The first three causes of bitter milk need not be discussed in this paper. It is probable that the bacteria causing bitterness are not at all uncommon and that they could be found in many lots of milk showing no bitterness. Some of these bacteria form acid and sour the milk; the more common forms, however, form little acid, and are checked by the growth of the lactic-acid bacteria. Nearly all of them form spores, and thus survive heating, which destroys the lactic-acid bacteria. For this reason bitterness has been most frequently observed in pasteurized and imperfectly sterilized milk. The few remaining spores germinate, and as they are unhindered by the presence of lactic-acid bacteria they soon reach unusual numbers and the bitter flavor appears.

The bacteria causing bitterness in unheated milk are more frequently those of the acid-forming classes, which are better able to compete with the lactic-acid bacteria. The acid formed by this group is usually butyric and not lactic. Some writers have stated that the bitterness is caused directly by the butyric acid. Nearly all of the bacteria known to produce bitterness bring about an active digestion of the casein and albumen, and it is probable that the bitter principle is formed in this decomposition. In most cases, however, the bitterness becomes evident before there is any visible sign of change in the milk.

Bitter milk may occur as an epidemic, persisting day after day and causing great trouble. This may be due to some constant localized source of infection which adds each day unusual numbers of bacteria to the milk. In some cases it has been found that the udder of a cow was infected. This should be determined by carefully cleaning the udders of all the cows and milking from each quarter of the udder of each cow into fruit jars or bottles which have been previously cleaned with boiling water.

In case one of these samples shows a well-developed bitterness while others remain normal, it may be assumed that the source of infection is the udder of the cow giving this milk. In that case there should be injected into the udder after each milking a solution of 1 part hyposulphite of soda in 100 parts of water.

It is probable in many cases that the source of infection is not localized. If through some combination of circumstances the lactic-acid bacteria are suppressed, other kinds become predominant. The utensils, the milk room, and the stable gradually become inoculated with these bacteria or their spores and each new lot of milk is thoroughly inoculated. The bitter-milk bacteria may be one of the new forms.

In this event it may be necessary, after thoroughly cleaning and steaming everything coming in contact with the milk, to introduce some good sour milk from a neighboring dairy. In this way the normal fermentation may be restored and the objectionable bacteria suppressed.

ROPY OR STRINGY MILK.

In this most troublesome fermentation the milk becomes what is commonly described as ropy or stringy. The milk is slimy and viscid. As this condition increases the milk may be drawn out into threads.

This fermentation should not be confused with garget, which appears in the fresh milk and is due to an inflammation of the udder. Ropy or stringy milk develops after the milk is drawn and is caused by the growth of certain kinds of bacteria. Although a number of kinds of bacteria causing this trouble have been studied as distinct varieties, it is probable that they are nearly all closely related. They do not form spores and are therefore destroyed by a comparatively low heat.

If a sample of ropy milk is examined under a microscope it is found to be filled with these small bacteria, each one surrounded by a capsule of a sticky, gummy substance. This gum or slime holds the bacteria together. When a thread is drawn out it is really a chain of bacteria held together by their sticky capsules.

Ropy milk is, so far as known, in no way detrimental to health. The famous Edam cheeses are nearly all made from milk which has undergone this fermentation. The peasants of Norway consider ropy milk a desirable beverage and bring about this fermentation by adding to fresh milk the leaves of certain plants on which the bacteria causing ropy milk are abundant. Most people, however, object seriously to milk with any tendency to form threads. This trouble frequently affects the milk of a dairy day after day and is removed only by the most drastic measures.

Outbreaks of this nature frequently occur in the cold months, because the bacteria of this group thrive better at low temperatures than the lactic-acid bacteria which hold them in check under normal conditions. In one case it was found that these bacteria were abundant in the dust of the stable. The trouble was removed by a thorough cleaning and whitewashing. In another serious and persistent outbreak it was found that the milk as it came from the dairy contained few or no ropy milk bacteria, but that they were abundant in the water tank in which the milk was held over night. The small amount of water occasionally splashed into the cans added sufficient bacteria to make the milk ropy in a comparatively short time. The utensils and floor had become so thoroughly impregnated with this organism that milk exposed in the room or strained through the wire strainer became ropy without contamination with the water. The trouble was removed by thoroughly scalding all the utensils, disinfecting the floor with a 5 per cent sulphuric acid solution, and destroying the organisms in the ice water by adding potassium bichromate. This was used in the proportion of 1 part in 1,000 or, roughly, 1 ounce to 1 cubic foot of water.

The source of the trouble can sometimes be easily located by taking small samples of the milk in clean glass jars at different stages in the handling. These should be covered, set away in a cool place to retard the souring, and examined after twenty-four to thirty-six hours for indications of ropiness.

In dairies getting milk from a number of farms the source of the difficulty may be located on some particular farm and proper methods taken to remove the source of contamination.

Any precaution is almost sure to be ineffectual if all utensils coming in contact with the milk are not thoroughly scalded, or, better still, steamed.

MISCELLANEOUS FERMENTATIONS.

In addition to the various fermentations previously described, milk may undergo many other changes as a result of the action of bacteria or other micro-organisms. The color may be changed. The appearance of color in milk is due to the growth of bacteria which produce a pigment soluble in water. All the colors of the rainbow, from bright red to violet, are formed by bacteria. Blue milk, which is the most common of the color fermentations, is probably due to contaminations from water, in which the blue and violet forming bacteria are known to occur frequently. It is only under unusual circumstances that these bacteria occur in milk in sufficient numbers to give any trouble.

Milk sometimes undergoes an alcoholic fermentation, and in some countries this is brought about by proper inoculation and control of temperature to produce a beverage. The alcoholic fermentation is usually caused by a yeast which has the ability to break up milk sugar into alcohol and large quantities of carbon dioxid gas. The ordinary yeast, such as is used in bread making, produces similar changes in cane sugar, but does not affect milk sugar. In the alcoholic drinks made from milk the alcoholic fermentation is usually combined with an acid fermentation. Koumiss, a drink made originally in the Caucasus from mare's milk, is a combination of an alcoholic and a lactic-acid fermentation. This drink is believed to be beneficial in some diseases of the stomach and is frequently made from cow's milk. When made in this way with ordinary yeast it is necessary to add cane sugar.

DISEASE-PRODUCING BACTERIA IN MILK.

It is now generally recognized that many of the diseases which may be communicated from one person to another are caused by specific bacteria. The organisms causing some of these diseases have not yet been discovered, but the causal bacteria of many have been isolated and studied in detail. Some of these diseases occur usually only in human beings, others occur usually in animals and are only occasionally transmitted to men, while others may occur with equal frequency in both man and animals.

It is well known that certain diseases are sometimes disseminated through milk. By this means an epidemic may appear suddenly and last for a comparatively short time, or the infection may be continued for a long period and the development of the disease be so slow and obscure that the source is unknown.

Tuberculosis is an example of the latter class. So much in regard to this disease is still unknown, so many widely separated views are held, even by those most familiar with the subject, that it is impossible to make positive statements. However, tuberculosis has been studied in such detail that many facts have been well established, and many theories advanced are so probable that they can not be disregarded until they are disproved.

The question of the identity of tuberculosis of man with that of animals has been raised, and while it is not yet accepted as a fact by all investigators, a large majority of the people whose opinion has weight believe that the two diseases are identical. Assuming that they are, much difference of opinion exists as to the possibility of transmission from cows to man through milk. It is well known that other animals, including calves and pigs, may be infected by drinking milk from tuberculous cows, and the possibility that man, and especially children, may become infected in this way is so great that to disregard it on the ground that it is still unproved is carelessness approaching criminal negligence. The tendency among those who are studying the question most carefully is to consider milk as a serious source of danger.

A number of epidemics of diphtheria and scarlet fever have been traced to the milk supply. In diseases of this nature the milk is infected by someone suffering from an attack of the disease, or through someone who has been in contact with the patient. Obviously no one suffering from a contagious disease, or one who is caring for a diseased person, should be allowed to go near the stables or milk room or handle milk utensils. The only really safe way is to enforce strict quarantine against farms where contagious diseases are known to exist.

Typhoid fever, while not classed as a contagious disease, is communicated from one person to another. The ordinary channel of communication is generally considered to be the drinking water, which may be contaminated by sewage, but occasionally it is disseminated through the food. Milk may become infected with this disease in various ways. Contaminated well or spring water may find its way into the milk through milk pails, cans, or bottles which were not thoroughly scalded after rinsing in cold water; the cans or bottles of milk may be left to cool in contaminated water and become inoculated by the accidental addition of even a few drops of water; the cows may wade in water or mud containing the typhoid bacillus and the small drops of muddy water which dry on the animal's flank may carry the organism to the milk; or flies may go directly from the waste from the sick room to the milk or milk utensils. It must be remembered that milk is an excellent medium for the growth of disease bacteria as well as the more harmless forms; and if temperature conditions permit, the comparatively few bacteria carried in a few drops of water, a speck of mud, or the legs of a fly begin to multiply and soon reach dangerous numbers.

In this connection must be considered the summer intestinal diseases of children. While the specific bacteria causing these troubles have not been recognized in all cases, it is generally accepted that they are carried by the milk and that this is the important factor in their control. It has been proved by careful observation and statistics that the death rate among babies in the crowded cities can be materially lessened by supplying them with good milk. It is believed that these troubles are caused not by single species, but by a group of digesting bacteria, which produce poisons in the milk, together with other decomposition products. This class of bacteria is typical of old milk, milk that has been handled in an insanitary manner, or not kept at a low temperature.

THE HANDLING AND CARE OF MILK.

Preventing changes in milk is a question of preventing the introduction of bacteria into milk and of checking their growth or destroying them when they are present. The production of milk reasonably free from bacteria is a simple question of cleanliness.

How far a milk producer can go in this direction with profit is a question that each one must decide for himself. The model dairies which are used as examples of what dairymen should do are frequently maintained in such an expensive manner that the farmer or dairyman doing a small business or producing milk in connection with other lines of farming can not expect to live up to their standards without increasing the cost of his milk.

However, there are many simple rules and methods for handling milk, requiring little extra labor and no added expense, which will materially increase the healthfulness and keeping quality of the product. Any precaution that reduces the dust in the stable at milking time reduces the initial number of bacteria in the milk. The cows should not be fed before milking. Cobwebs and other dirt can be easily removed from the ceiling. The stable floor should be so arranged that the dirt on the flanks and udders of the cows will be reduced to a minimum. The daily use of a brush will add greatly to the efficiency of these precautions. Care should be taken that the cows do not have to wade through filth in the barnyard.

Even with the greatest precaution some bacteria get into the milk, and further precautions must be taken to prevent their undue multiplication. The practical way to accomplish this is by control of the temperature of the milk. Advantage is taken of the natural law governing the limits and rapidity of growth of bacteria at different temperatures. The milk should be cooled at once to a temperature as near the freezing point as circumstances will permit. The usual limit is 50° F., but 40° F. is much more desirable.

The quickest and most economical method is to run the milk in a thin layer over the surface of a receptacle containing cold water. Many varieties of coolers for this purpose are on the market. Some are so arranged that a stream of water passes through them, while in others the milk flows over a conical tank containing cold water. A cooler should be located in a clean, well-ventilated room, or the benefits of cooling will be overcome by contamination from dust and the absorption of bad odors.

On farms where water is supplied by a windmill it is very easy to arrange the water trough so that the water flows from the pump through a trough or tank in which the cans of milk may be set to cool. This is a slow method, but much better than nothing.

It is not sufficient merely to cool the fresh milk. To insure good results it must be kept cold until used. The housekeeper who leaves her bottles of milk in the sun or standing in a warm kitchen should not blame the milkman for sour milk.

Various attempts have been made to preserve milk by holding it above instead of below the temperature favorable to the growth of bacteria. Devices for this purpose are called thermophores. While the most favorable temperature for many bacteria is at or near 98° F., few grow well at temperatures a few degrees above this point, and at 110° to 120° ordinary forms will not grow at all.

Milk held in thermophores usually will not curdle or change appreciably for several days, but it has been shown that unusual kinds of bacteria are able to develop at these high temperatures and that the milk which has every appearance of being good may contain large numbers of bacteria whose action is unknown. Devices for keeping infants' milk warm through the night should never be used.

Chemicals having an injurious effect on bacteria are sometimes used to retard the growth of bacteria in milk and thus prolong the time within which it may be sold. This practice is so universally condemned by public opinion that it need not be discussed here.

Heat is frequently applied to milk to destroy a part or all of the bacteria. Complete destruction of all bacteria in any substance is sterilization; pasteurization is a term used to designate a process by which milk or other fluids are heated to destroy part, but not all, of the bacteria. Pasteurization may be "continuous" or "intermittent;" in the first method the milk flows in a continuous stream through the pasteurizer, where it is heated to the required temperature by steam or hot water; in the second method the milk is heated in a similar way, but is held at the pasteurizing temperature for some time.

The temperature for pasteurizing varies greatly. As a general rule, to insure good results, the temperature must be increased as length of exposure is decreased. When the milk is held for twenty to thirty minutes the temperature may vary from 140° to 160° F. The former temperature is the lowest point at which the bacillus of tuberculosis is destroyed. To make the destruction of this bacillus certain the milk must be held at 140° for at least twenty-five minutes and be constantly stirred. In the continuous machines, where the milk is maintained at the pasteurizing temperature usually for only twenty-five or thirty seconds, the temperatures used range from 160° F. to 185° F. The results at 160° F. are uncertain, and any temperature below this point has little or no beneficial effect. Milk may be efficiently pasteurized in the household by setting the bottle of milk in a vessel containing water, and heating the water until the milk reaches a temperature of about 150°. It may then be removed from the stove and allowed to stand for twenty to twenty-five minutes. The temperature of the water will be above that of the milk, and while it slowly cools the milk will be thoroughly heated. It should then be chilled at once and kept cold until used.

Pasteurization should not be confused with sterilization. Even when the former is efficiently done, the vegetative or growing bacteria only are killed. Spores may resist boiling for several hours, and it is unusual to find milk entirely free from spores. Under proper temperature conditions these soon germinate and the milk may in a short time be worse than before pasteurization. In other words, pasteurized milk must be kept from contamination and warmth as well as the unpasteurized product.

Milk may be sterilized by repeated boilings. This is usually accomplished by steaming on three or four successive days. After each boiling it should be held at room temperature for twenty-four hours to allow the spores to germinate and reach the vegetative stage.

Sterilization may be effected in one operation by exposure to a temperature above the boiling point. To effect this exposure it is necessary to hold the milk in a closed chamber with steam under pressure.

Milk can also be sterilized by chemical means. The so-called "Buddeized" milk is sterilized by adding a small amount of hydrogen peroxid, which acts energetically on bacteria and is itself slowly decomposed into two harmless substances, oxygen and water. Milk treated in this way is said to be not entirely free from an objectionable taste and the sterilization is not always certain.

While bacteria are in no way essential to milk, they may be considered as normally present in milk, cream, ice cream, butter, and cheese. They may even occur in milk or its products in very large numbers without making it an unsafe food or in any way decreasing its food value.

Bacteria known to produce disease are seldom isolated from or counted in milk, and bacteriological counts should be taken merely as an indication of the way in which milk has been collected or the temperature at which it has been held. High numbers usually indicate insanitary conditions, careless handling, or old milk. However, milk may be collected under very poor conditions and the bacterial count held down by a liberal use of ice. On the other hand, milk collected in the most sanitary manner may in a few hours contain a large number of bacteria if it is held at a high temperature. Low counts may be due not to clean stables and low temperatures, but to the use of antiseptics.

Every effort should be made by legitimate means to secure milk with a small number of bacteria, but milk or foods made from milk should not be indiscriminately condemned because they sometimes contain bacteria in numbers which are startling to those not familiar with the nature of these indispensable plants.

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Issued February 11, 1909.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 349.

THE DAIRY INDUSTRY IN THE SOUTH.

BY

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Dairy Division, Bureau of Animal Industry.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Animal Industry,
Washington, D. C., December 9, 1908.

Sir: I respectfully transmit herewith a series of papers relating to "The Dairy Industry in the South," prepared by Messrs. B. H. Rawl, Duncan Stuart, and George M. Whitaker, of the Dairy Division of this Bureau.

In 1906 the Dairy Division began systematic field work in the Southern States for the development of the dairy industry in that section. This work has been carried on in cooperation with State experiment stations, agricultural colleges, and departments of agriculture, and has steadily increased until at present a representative of the Dairy Division is working in each of nine Southern States. The work has consisted largely of personal effort among the dairy farmers with a view to teaching them better methods, and has produced good results.

Fundamental to any question of production is the question of markets, and in order that the field workers might properly advise dairymen regarding the marketing of their products it was found necessary to make a systematic study of this subject. Consequently, during the fall of 1906 and the following winter, a representative of the division made a close inspection of the markets of 50 cities, the results of which are shown in the first paper. Prices were generally lower when this inspection was made than they were in 1907–8, but other conditions have not materially changed.

In the prosecution of this work it was realized that a decided improvement in the quality of the milk supply of the cities throughout the South was needed. Insanitary methods of producing and handling milk were a great menace to public health. In 1907 an inspector was assigned to investigate the situation more fully and give assistance in applying methods that would bring about improvement. The second paper discusses various phases of this question.

The report on markets shows that only a small part of the dairy products consumed in the South are produced in that section. A preliminary survey of the whole field was made in 1905 by Mr. Rawl, following which Congress made a special appropriation to prosecute this work on a more extended scale. This support by Congress has since been continued in the general appropriation for the Bureau of Animal Industry. The third paper describes the conditions which seem to be responsible for this small production of dairy products in the Southern States, and tells why dairying has remained an undeveloped industry in that section of the country.

These papers form a part of the Twenty-fourth Annual Report of the Bureau, but as they deal with a subject of great interest and importance to a large section of the country I respectfully recommend that they be made available for a wider distribution by reissuing them as a Farmers' Bulletin.

Respectfully,
A. D. Melvin,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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THE DAIRY INDUSTRY IN THE SOUTH.

SOUTHERN MARKETS FOR DAIRY PRODUCTS.

By Duncan Stuart,
Assistant in Dairying, Dairy Division, Bureau of Animal Industry.

During several months in 1906–7, 50 of the larger cities in 13 States of the South were visited by the writer in order to obtain data relative to the dairy markets of that part of the country. Statistics were collected as to the amounts of butter, cheese, milk, condensed milk, and cream handled in these cities, and an attempt was made to determine what proportion of these amounts was brought in from the Northern and Western States. Table 6 shows how small a part of the butter and cheese consumed in this territory is produced by southern dairymen. In looking over these figures it must be borne in mind also that the prices obtained at that time (1906–7) were lower than at the present time (1908), hence the amounts that could be saved by home production of these articles would be even greater now.

During the past year, however, many new creameries have been established, particularly in Kentucky and Texas. The census of 1900 reported 7 creameries in Kentucky; the census of 1905 reported only 3; while in the spring of 1908 reports show that there are 42. These facts indicate that the dairy industry is advancing and is becoming of more importance in the States under consideration.

BUTTER.

Creamery Butter of the South.

The creamery butter production of the South is entirely inadequate to meet the demand, there being only a few regular creameries in the Southern States. It will be seen from Tables 1 and 4 that the quantity made is less than one-twentieth of that brought in. One creamery, at Fort Worth, Tex., uses cream from long distances in that State, and in addition gets a part of its supply from points in Oklahoma. Chattanooga, Tenn., also has creameries of this kind. The southern creameries are making a grade of butter which sells for a price equal to that of the best northern and western product. Large amounts of print butter are shipped in by the butter companies of Illinois, Wisconsin, and Kansas; tub butter also is used extensively, the larger retail stores using the "cut-to-weight" butter cutters. Some butter is made in cities by the large milk plants, which turn their surplus milk and cream into butter. This fresh butter is put up in attractive prints and finds a ready sale among the milk customers.

Butter is shipped in refrigerator cars to the larger trade centers and from these points is reshipped to the smaller towns, usually without refrigeration. The great disadvantage of the butter business of the South is the lack of proper equipment for handling the commodity. The small retail stores often do not have proper cooling facilities, consequently the butter is soft and in many cases has become rancid before it is sold to the consumer.

It will be noted in Table 4 that about 23,435,000 pounds of creamery butter annually is brought in from Northern and Western States.

The census of 1900 reported the production of creamery and dairy butter in the South as follows:

TABLE 1.—*Production of creamery and farm butter in Southern States, census of 1900.*

State.	Butter made on farms.	Butter made in creameries.
	Pounds.	*Pounds.*
Alabama	19,121,964	17,357
Arkansas	21,585,258	168,575
Florida	1,386,445	....
Georgia	15,111,494	48,960
Kentucky	30,446,381	184,663
Louisiana	4,918,229	....
Mississippi	18,881,236	48,525
North Carolina	16,913,802	....
South Carolina	8,150,437	....
Tennessee	29,091,696	207,823
Texas	47,991,492	252,714
Virginia	19,905,830	170,521
West Virginia	16,913,129	41,000
Total	250,417,393	1,140,138

From the above figures it will be noted that of the total amount of butter produced in the South in 1899, only a very small part was made in creameries. It may be stated also that the relative proportion has not materially changed since.

Dairy and Country Butter.

The quality of the dairy butter varies greatly. Some of the better dairies are making a product almost, if not quite, equal to the best creamery butter. It is delivered to the consumers in pound prints neatly wrapped in parchment paper and bearing the monogram or name of the dairy. Though this grade of butter is comparatively limited in quantity, it is now being supplied to the following cities by the near-by dairymen: Shreveport, La.; Raleigh, N. C.; Columbia, S. C.; Macon, Augusta, and Atlanta, Ga.; Tallahassee, Fla.; Montgomery and Birmingham, Ala.; Dallas, Austin, and San Antonio, Tex.

A large amount of dairy butter is shipped to the Carolinas and to Georgia from Tennessee in 5-pound and 10-pound tin pails. Some dairy butter made in Georgia has been shipped to market in South Carolina and sold there as Tennessee butter.

Of quite a different grade is the butter that is handled by the country merchant. This butter is brought to him in various shapes—in boxes, round prints, rolls, etc.—and in various shades of color. He retails what he can of it, and the balance he ships in tin cans or in barrels to the commission men in the large cities. By the time it reaches them it is apt to be very rancid, as a result of not having been properly washed when it was churned. One needs only to visit these commission merchants to see a product resembling axle grease more than butter. This quality of butter is bought as low as 7 cents a pound. The butter dealers of Austin, San Antonio, and Fort Worth, Tex., together ship annually about 300,000 pounds of this grade of butter to the renovating factories.

The butter produced in the South, even if it were all of the best quality, is of insufficient quantity to meet the demand; yet a large part of that which is produced has to be shipped to the renovating factories, as noted above, and treated by them before it is actually consumed. We see, therefore, that an advance must be made in the methods of manufacture, as well as in the amount turned out, before southern butter can meet the demands of consumers in that section.

Renovated Butter.

Quite a large amount of the butter consumed in the South is renovated or "process" butter. Reports gathered from 50 cities show an annual consumption of about 7,163,000 pounds, while the production of the renovating factories in that section of the country is only about 33,300 pounds.

Renovated butter is retailed at an average price of 26 cents a pound, much of it selling for 30 cents, and during the past winter (1907–8) it has sold as high as 35 cents a pound. Using the average price of 26 cents a pound, the annual value of the sales of this grade of butter amounts to about $1,862,300 for 39 cities. Inasmuch as renovated butter can be bought at a lower price than creamery butter there is a great temptation to sell it as creamery butter, and some dealers are undoubtedly doing this.

OLEOMARGARIN.

The Fifty-sixth Congress, second session, in Senate Report 2043, under date of January 26, 1901, published data furnished by the Treasury Department from its figures for the year 1899 showing the amount of oleomargarin shipped into the various States. At that time 11.5 per cent of the total amount consumed was used in the South.

Since the act of May 9, 1902, which imposed a tax of 10 cents a pound on the colored product and one-fourth of a cent on the uncolored, the consumption of oleomargarin has decreased. However, the consumption of this article is still great in some of the larger cities, especially in the winter season. Large amounts are handled in Norfolk, Richmond, Charlottesville, and Lynchburg, Va.; Chattanooga, Nashville, and Memphis, Tenn.; and Louisville, Lexington, Newport, and Covington, Ky. One of these cities uses as much as 700,000 pounds annually.

The colored product retails as high as 32 cents a pound, while the uncolored retails at an average of from 15 to 20 cents. Of the amount consumed in the South less than 8 per cent is manufactured in that section.

The scarcity of creamery butter in the winter season, and the unevenness of color and the tendency to rancidity which characterize the country butter, account for the large consumption of the better grades of oleomargarin.

The following table shows the amounts of oleomargarin used by States in 1899 (according to the census of 1900) and the approximate amounts used in the fiscal year 1905–6:

TABLE 2.—*Quantity of oleomargarin shipped into Southern States in 1899 and in fiscal year 1905–6.*

State.	1899.	Fiscal year 1905–6.
	Pounds.	*Pounds.*
Alabama	226,053	347,488
Arkansas	380,389	257,141
Florida	590,225	145,827
Georgia	495,004	172,494
Kentucky	1,490,577	1,286,402
Louisiana	1,043,502	345,847
Mississippi	104,622	61,289
North Carolina	110,244	125,605
South Carolina	258,159	72,843
Tennessee	714,640	475,867
Texas	1,518,264	570,088
Virginia	1,159,400	1,326,152
West Virginia	1,206,865	1,579,180
Total	9,297,944	6,766,223

CHEESE.

Practically no whole-milk cheese, or cheese of the Cheddar type, is manufactured in the South. A few small factories are reported in South Carolina (two at Easley), Virginia, and West Virginia, but the output of these factories is very insignificant in comparison with the large amount consumed. In the 50 cities visited in 13 States the cheese handled amounted to approximately 42,000,000 pounds annually, while the production in the States mentioned, as indicated by the census figures, was probably less than 2 per cent of this total. The per capita consumption of cheese in the South is quite considerable, as large quantities are used by the laboring classes, who depend largely on crackers and cheese for their midday lunch.

Large amounts of imported and American-made cheese of foreign types are consumed in many of the cities. Large quantities of Roquefort, Camembert, Swiss, Brick, Gorgonzola, Parmesan, Limburg, and Roman cheese are used. Roman cheese is especially popular in New Orleans, while cheese imported from Sicily is used to a large extent in Tampa, Fla. The so-called cream cheese, made by putting clabbered milk into molds to drain, is used in great quantities as a breakfast dish in New Orleans. Texas cities handle large amounts of Brick cheese, but they also consume much of the imported varieties, especially during the cool weather.

The "daisy" type of Cheddar cheese is popular. Being a small cheese—20 to 23 pounds—it is easily handled during the hot season, and in addition is readily cut by the automatic cheese-cutting machines. "Flats" and "twins" are used to some extent in cool weather in the extreme Southern States, and to a larger degree in the Carolinas, Kentucky, and Tennessee.

Whole-milk cheese usually retails at 20 to 25 cents a pound, but in a few cities it is retailed as low as 17 cents a pound. Skim-milk cheese is being sold to some extent and is not always correctly branded. New York State cheese and Wisconsin cheese are the principal ones on the southern market.

The census of 1900 gives the following figures on the cheese production of the Southern States:

TABLE 3.—*Quantity of cheese produced in Southern States, census of 1900.*

State.	Cheese made on farms.	Cheese made in factories.
	Pounds.	*Pounds.*
Alabama	36,374	10,000
Arkansas	18,385	12,600
Florida	3,751	
Georgia	2,236	
Kentucky	45,759	28,000
Louisiana	135,104	
Mississippi	28,272	
North Carolina	28,883	
South Carolina	1,081	
Tennessee	26,622	6,201
Texas	136,133	58,290
Virginia	31,697	57,000
West Virginia	74,243	40,860
Total	568,540	212,951

From the above figures it will be seen that the cheese production of the South is wholly inadequate to the supply needed for consumption. The estimated amounts consumed in the larger cities of the above States, as shown in Table 4, totaled 41,582,545 pounds.

ICE CREAM.

There is a heavy ice cream consumption in southern cities. Much of the product, however, is of low grade, being made from whole milk and from bulk condensed milk. The price varies from 70 cents to $3 a gallon, the latter price being paid for a fancy grade of cream put up in special forms. The average retail price is about $1.50 a gallon.

The following are some of the cities manufacturing large amounts of ice cream: Memphis, Chattanooga, and Nashville, Tenn.; Little Rock, Ark.; Fort Worth, San Antonio, and Dallas, Tex.; Louisville, Ky.; Jackson, Miss.; Birmingham, Ala.; and Macon and Atlanta, Ga. Memphis ships the largest amount, one of its manufacturers making as high as 3,000 gallons in one day in the summer season. Ice cream manufactured in Tennessee and Georgia is shipped to points as far south as Florida.

CREAM.

In the South the consumption of cream is small. This is due to the scarcity of fresh cream rather than to a lack of demand for this dairy product. The cream sold is also quite variable in quality, some of it being only equal to a rich milk. Much unsweetened condensed milk is used in the place of cream. The fresh cream in some cities is supplied by near-by dairymen, while others get it from long distances. The larger cities of Georgia, with the exception of Savannah, are fairly well supplied with cream. Newport and Covington, Ky., get a part of their supply from Cincinnati dealers, while Louisville gets cream by rail from Illinois and Indiana. The North Carolina cities depend largely on local product; however, a small amount is shipped in from Virginia. Tennessee cities, with the exception of Memphis, are well supplied with local product. Texas cities, excepting Fort Worth, are also supplied from within the State.

Mobile, Ala., gets a part of its supply from Tennessee; all the larger cities of Florida, with the exception of Tallahassee, get a large part of their cream from points in Georgia and Tennessee; a portion of the supply for New Orleans comes from Tennessee and Illinois; Jackson, Miss., gets a small supply from Tennessee; Memphis gets a part of its supply from Mississippi and Arkansas; and Norfolk, Portsmouth, and Richmond, Va., receive fresh cream from New York City; Wilmington, N. C., Jacksonville and St. Augustine, Fla., and Galveston, Tex., depend largely on unsweetened condensed milk.

CONDENSED MILK.

Condensed milk is consumed in large quantities in southern cities and to some extent on the farms. It is put up in small cans selling for 5 and 10 cents each, but is also sold in larger sizes. The smaller sizes are very convenient for family use during the hot season. In many sections the supply of fresh milk is unsuitable for infant feeding and the physician invariably recommends condensed milk.

Fresh cream being scarce, condensed milk is used as a substitute. This is used as cream and is also manufactured into ice cream. Unsweetened condensed milk is received in 10-gallon cans at Jacksonville from New York City. Memphis gets bulk condensed milk from Arkansas. St. Augustine and Galveston also use large amounts of the unsweetened product.

QUANTITIES AND PRICES OF DAIRY PRODUCTS.

The following tables give data regarding the dairy markets of the 50 cities, in 13 States of the South, discussed in the preceding pages:

TABLE 4.—*Quantity of dairy products handled in 50 southern cities, fiscal year 1905–6.*

City.	Approximate quantity handled of—					Milk sold daily.	
	Creamery butter.	Renovated butter.	Oleomargarin.[a]	Cheese.	Condensed milk.	Quantity.	Amount bottled.
Arkansas:	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Gallons.*	*Per cent.*
Fort Smith	126,000	15,000	26,100	572,000	291,360	200	....
Little Rock	500,000	100,000	51,000	800,000	499,200	3,300	10
Alabama:							
Birmingham	291,205	278,000	136,000	1,767,520	1,453,680	1,735	33
Mobile	882,400	118,000	49,300	916,000	1,227,600	1,100	....
Montgomery	153,708	124,540	76,000	1,203,000	425,040	600	....
Florida:							
Jacksonville	1,500,000	200,000	150,000	1,675,650	2,803,200	1,250	50
Pensacola	449,340	28,541	17,800	297,120	610,800	450	....
St. Augustine	....	([b])	2,000	....	....	400	....
Tallahassee	9,000	....	....	41,760	27,360	150	....
Tampa	742,070	91,600	18,550	400,830	2,683,680	1,500	75
Georgia:							
Atlanta	630,000	20,000	61,000	2,117,500	1,126,320	5,000	....
Augusta	380,100	(?)	8,440	1,289,500	....	1,200	....
Macon	97,740	98,000	12,900	1,395,950	362,592	800	....
Savannah	96,900	229,263	52,730	946,307	1,536,000	....	....
Valdosta	102,750	34,000	600	185,000	122,208	200	....
Kentucky:							
Covington	190,000	60,000	92,900	250,000	....	2,500	33
Lexington	50,000	....	162,440	270,000	48,000	2,500	50
Louisville	2,000,000	500,000	699,000	2,000,000	888,000	10,000	60
Newport	150,000	50,000	69,000	150,000	....	1,750	....
Louisiana:							
Baton Rouge	43,500	26,300	19,200	98,000	416,640	....	....
New Orleans	4,700,000	800,000	187,463	2,069,976	12,480,000	16,000	....
Shreveport	60,700	28,000	37,840	612,000	708,000	1,100	....
Mississippi:							
Jackson	58,000	24,000	6,900	192,000	157,440	510	....
Meridian	15,000	23,150	6,300	627,530	192,000	300	....
Natchez	82,588	14,226	3,900	255,245	601,200	375	....
Vicksburg	156,884	122,763	8,600	389,560	614,400	580	....
North Carolina:							
Asheville	20,000	....	14,400	120,000	40,320	800	....
Charlotte	14,600	....	1,350	543,000	(?)	675	25
Greensboro	18,390	....	10,700	267,600	(?)	....	....
Raleigh	26,676	2,000	19,750	203,750	(?)	250	....
Wilmington	421,700	59,000	8,400	547,000	(?)	....	40
South Carolina:							
Charleston	900,000	600,000	25,214	1,063,415	1,341,600	....	....
Columbia	218,540	50,000	27,300	253,680	357,696	400	....
Tennessee:							
Chattanooga	425,040	88,380	74,000	773,742	1,992,000	2,200	50
Knoxville	50,000	5,000	46,700	400,000	105,600	2,000	25
Memphis	1,314,420	416,100	107,300	4,000,000	1,805,760	8,750	75
Nashville	248,100	....	98,000	1,146,200	168,000	....	....
Texas:							
Austin	1,000	....	25,000	530,000	144,000	....	....
Dallas	350,000	10,000	79,490	750,000	768,480	2,000	....
Fort Worth	531,250	186,730	53,500	650,000	566,400	1,600	....
Houston	908,460	515,608	59,700	1,037,540	2,231,136	....	....
Galveston	878,000	164,500	50,000	791,300	960,000	1,120	....
San Antonio	116,660	....	54,000	682,870	703,200	4,000	....
Waco	27,500	....	16,000	450,000	315,216	....	33
West Virginia:							
Charleston	286,720	125,000	25,214	430,000	480,000	600	....
Virginia:							
Charlottesville	20,000	5,000	20,050	75,000	33,600	....	....
Lynchburg	40,000	....	87,220	245,000	72,960	800	....
Norfolk	2,250,000	1,500,000	113,414	4,000,000	(?)	2,000	....
Portsmouth	150,000	150,000	12,700	100,000	(?)	600	....
Richmond	750,000	300,000	376,118	2,000,000	1,200,000	5,000	....
Total	23,434,941	7,162,701	3,361,483	41,582,545	42,560,688	....	....

[a] Consumed.

[b] St. Augustine included in Jacksonville report.

TABLE 5.—*Wholesale and retail prices of dairy products handled in 50 southern cities, fiscal year 1905–6.*

City.	Milk.			Cream.			Butter.		
	Paid to producer, per gallon.	Retail, per gallon.	Retail, per quart.	Paid to producer, per gallon.	Retail, per quart.	Fat.	Creamery, per pound.	Dairy or country, per pound.	Renovated, per pound.
Arkansas:	*Cents.*	*Cents.*	*Cents.*		*Cents.*	*Per ct.*	*Cents*	*Cents.*	*Cents.*
Fort Smith	11½–15	25	7–8⅓	$1.00	35		35	25	20–25
Little Rock	12½–15	20–25	6⅔–8⅓	$0.80–1.00	30 40	20 30	30–35	25	25
Alabama:									
Birmingham	15–20	20–25	8⅓–10	.80–1.00	40	30	30–35	25–35	25–30
Mobile		25–30	8⅓–10	2.00 1.25		26 20	30–35		25–30
Montgomery		18–20	6¼–8	.80– .90	40	20	33	25–30	25–30
Florida:									
Jacksonville		25–30	8–10		40		33–35		28–30
Pensacola		35	10		40				
St. Augustine		32	10	1.20	40	30	35–40		25
Tallahassee			8⅓–10		40		35	25–30	
Tampa	25–27	35	9–10	1.00	40	20	35	35–40	30
Georgia:									
Atlanta	20–25	30	8⅓–10		30–40		30–35	25–40	
Augusta		25	10	1.00	40	25	32–35	30	30
Macon			8⅓	1.00	40	25	33	25–30	
Savannah		25–30	8⅓–10	2.00	50–60		35	25–30	25
Valdosta		30	10		25		35–40	25–35	
Kentucky:									
Covington			6–8	.80	24–30			25–30	
Lexington			6–8	.60	30	20	30–40		25–30
Louisville	11–15		7½–10	.60	30 25	25 20	30–35	12–30	27
Newport	18–20	25	7–8	.70	24–30		30–35	25–30	25
Louisiana:									
Baton Rouge		25	10		40		30–35		
New Orleans	14–16	20–25	7½–10	.80	30–40	20	32–35	30	
Shreveport		30	7½–10		50	25	35–40	25–30	
Mississippi:									
Jackson		25	7½–10	.75	25		30–35	15–30	
Meridian			10	1.00			35–37½	15–30	
Natchez		25	8–10	1.00	40		37½	25–30	
Vicksburg		24–32	8–10	.90–1.20			28–35	18–25	
North Carolina:									
Asheville		20–25	7–10	1.00 1.50		18–20 30	30–35	25–30	
Charlotte	15	25	10	1.20	40		35–40	7–35	15–30
Greensboro		17–20	6–10	.90–1.25	25–40		30–35	12–30	25
Raleigh		25	8⅓–10	1.00	50	25–30	30–35	25–35	
Wilmington			10–12	2.00	50–60		30–40	25–30	25–30
South Carolina:									
Charleston	20–24		8–10		60	30	30–35	25	25
Columbia		24	7–10		50		28–35	10–30	25–30
Tennessee:									
Chattanooga	13–17	25	7–8⅓	.80–1.00	35	20	35	20–25	25–30
Knoxville		20–25	7–8		32	20–22	30–35	25–30	
Memphis	14–17		7–10		25	20	35	25	25
Nashville	13–18		5–8	1.00	25–30	12½–30	30	28	
Texas:									
Austin		20–25	5–7½	1.00			30–35	10–30	
Dallas		20–25	8⅓	1.00–2.00	40	35	30–35	25–35	25
Fort Worth		20	7	1.00	30	25	27–30	8–30	20–25
Houston		20–25	7½–10	.75–1.20			30–35	20–30	
Galveston			6–10	.75–1.00			35	25–30	30
San Antonio	15–18	25	7–8	.75	30–40	25	25–35	10–30	15–30
Waco			5–7½	1.00	25		30–35	10–30	
West Virginia:									
Charleston		25	8–10		30		30–40	25–30	
Virginia:									
Charlottesville		24	6–8	1.00	30	15	30–35	20–25	
Lynchburg			10		25		33	20–25	
Norfolk			10		40		30–35	30	30
Portsmouth		25	8–10	.80–1.00	40				
Richmond	15–19	24–28	7–10	.85–1.00	40	25	35	15–35	

TABLE 5.—*Wholesale and retail prices of dairy products handled in 50 southern cities, fiscal year 1905–6*—Continued.

City.	Oleomargarin, per pound.	Cheese.		Ice cream.		Buttermilk, per gallon.	Skim milk, per gallon.
		Retail, per pound.	Wholesale, per pound.	Retail, per gallon.	Wholesale, per gallon.		
Arkansas:	*Cents.*	*Cents.*	*Cents.*			*Cents.*	*Cents.*
Fort Smith	15–25	20–25	17	$1.00	$0.70	10–12	10–12
Little Rock	15–25	....	....	$1.00–1.50	.65– .85	12½–15	10
Alabama:							
Birmingham	15–25	20	16	1.50	.70– .90	10–15	10–12½
Mobile	15–25	18–20	....	1.25–2.00	1.00	10–12½	10–12½
Montgomery	15–25	19–20	14–15	1.00–1.25	....	10–15	10–15
Florida:							
Jacksonville	20–25	20	....	1.50	....	....	....
Pensacola	....	....	....	2.00	....	....	....
St. Augustine	15–25	20	15	1.20	....	....	....
Tallahassee	....	20	15	1.50	....	10	10
Tampa	....	20	....	1.50	1.00	20	20
Georgia:							
Atlanta	....	20	....	1.50–3.00	....	15	12½
Augusta	....	17½–20	....	1.50	....	12–15	....
Macon	20	20	14½	1.25–2.00	.80–1.15	10–15	No sale.
Savannah	....	20	15	....	....	....	....
Valdosta	....	20	15	1.60	1.20	15	....
Kentucky:							
Covington	....	....	....	....	....	10	10–12
Lexington	15–25	20	15–16	1.00	.75– .85	10	10
Louisville	12½–25	18–20	16	....	....	15	15
Newport	15–22½	....	......	1.50	1.00	10	10–12
Louisiana:							
Baton Rouge	15	....	15	1.50	1.00	20	15
New Orleans	15–25	20–25	15	1.50–2.00	.75–1.00	10–12	....
Shreveport	....	20–25	14–17½	1.25–2.00	....	15	....
Mississippi:							
Jackson	20–25	20	16	1.25–2.00	1.00	....	....
Meridian	....	20–22⅓	15–16	1.50–2.00	....	....	....
Natchez	....	20	16½	1.25–2.00	....	....	....
Vicksburg	15	20	....	....	....	....	....
North Carolina:							
Asheville	....	20	....	....	.80–1.25	10	10
Charlotte	15–20	17½–20	....	1.30–1.50	1.00	10	15
Greensboro	....	20	....	1.00	....	10	10
Raleigh	15–20	17½–20	....	1.00–2.00	....	15	....
Wilmington	....	20	15	1.50	1.00	20	20
South Carolina:							
Charleston	15–25	20–22	....	1.40	....	....	....
Columbia	....	20	16	1.50	....	10	....
Tennessee:							
Chattanooga	25	20	15–16	1.25–1.50	.75– .90	10–15	4–10
Knoxville	20	20	14–15	1.00–1.25	.75–1.00	10	5–10
Memphis	20–25	20	14–15	1.25	.70–1.00	10	10
Nashville	25	20	15	1.00–1.50	.75– .90	....	....
Texas:							
Austin	....	20	15–16	....	....	10–15	10
Dallas	....	20	15	1.00–2.00	.75–1.00	10–12½	....
Fort Worth	12½–25	20	16	1.00–1.50	.75–1.00	10	12½
Houston	15–20	17½–20	....	1.00–2.00	....	15–20	5–6
Galveston	....	18–25	....	1.25	.75–1.00	15–20	12½
San Antonio	....	20	....	1.00–1.50	.70– .80	12–15	10
Waco	....	....	....	1.00	.50– .70	10	5
West Virginia:							
Charleston	15–25	15–20	....	1.25	....	15	....
Virginia:							
Charlottesville	12½–20	20	15	1.00–1.25	1.00	10	10
Lynchburg	15	20	14–15	1.50	1.00	15–16	....
Norfolk	15–32	18	14	1.50–2.00	.65–1.00	20	....
Portsmouth	....	....	....	1.00–1.50	....	....	....
Richmond	15–25	....	....	1.50	1.00	14	....

THE MILK SUPPLY OF SOUTHERN CITIES.

By George M. Whitaker,
Inspector, Dairy Division, Bureau of Animal Industry.

PRODUCTION.

Most of the milk supply of southern cities is produced within a few miles of the place of consumption. Many herds are kept within the thickly settled portions of the cities, where land is expensive. This generally means overcrowded stables, poorly lighted and ventilated, with contracted yards for exercise, filthy at all times, and almost knee-deep with mud after a rain. The feed used in these dairies is largely such as does not call for much storage space and is influenced to some extent by local conditions of production. Many city herds are fed nothing but cotton-seed meal and hulls. In some instances wheat bran is added. In cities where distilleries are located distillery slop is fed, though the trend of city ordinances is in opposition to this. Where there are breweries, brewer's grains are prominent in the dairy ration. Sometimes the grains are reduced to a thin slop with warm water. On account of the readiness with which the grains ferment some health boards prohibit the use of wet grains.

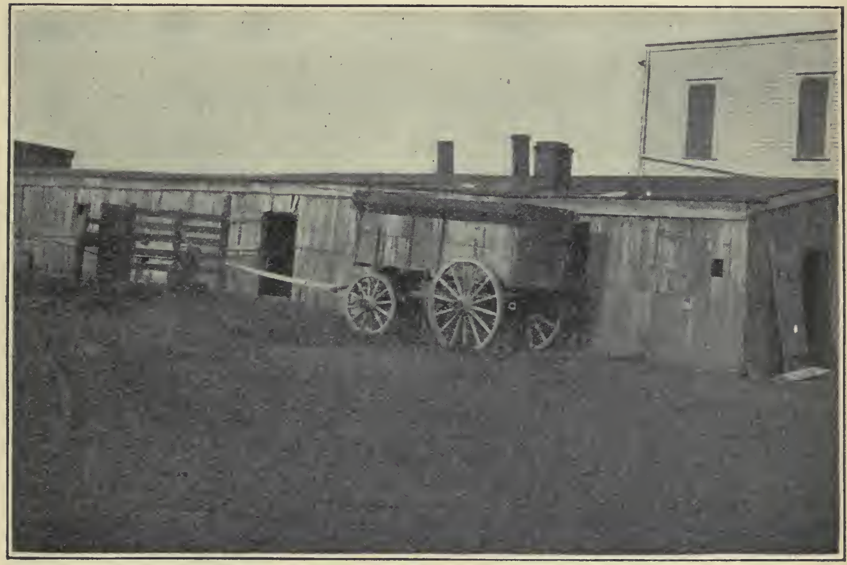

Fig. 1.—Cow stable in southern city, showing poor lighting and ventilation.

As the dairies are farther removed from the thickly settled portions of the cities to locations where land is less valuable the cows get more green feed in season, according to conditions. In some places a small bunch of green fodder of some kind is fed in the manger; in others the cows are allowed an hour's run each morning in a field of growing wheat. At still greater distances increasing amounts of green fodder are fed, though soiling as a system has made but little progress; and where the land is within an easy drive of the city and cheap enough there is some pasturage.

CARE OF MILK AT DAIRY.

Generally speaking, milk is not properly cooled by producers. The use of ice is unknown among the ordinary dairies. Some producers run the milk over a cooler supplied with spring water of a temperature rarely below 65° F. and frequently as high as 75°. Others set the cans of milk in tanks of spring water or in the running spring water. Other dairymen make no pretense of cooling the milk and can or bottle it for market at the natural animal temperature. The cooler, when used, sometimes stands in the stable (fig. 2), and frequently the milk is strained into the shipping cans behind the cows. Bottling is often done in rooms connected with the stable or in places where cleanliness is impossible (fig. 3).

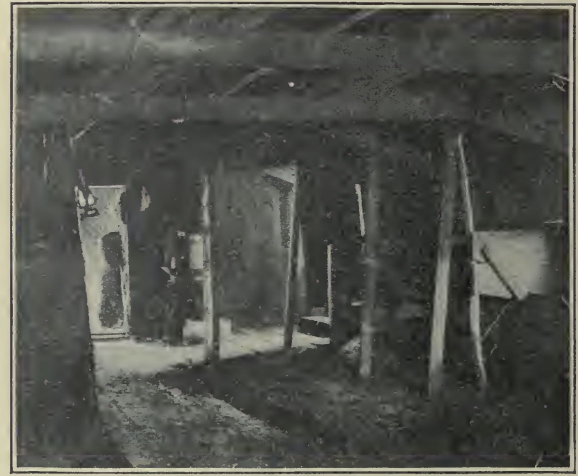

Fig. 2.—Insanitary location of milk cooler in barn.

Because the climate is generally mild and at times very warm much work is done out of doors. This frequently results in insanitary ways of handling milk utensils and the milk itself. For instance, when water for cleansing utensils and bottles is heated in an old pail set up out of doors on a few loose bricks the presumption against proper sterilization of milk receptacles at that dairy is strong. Many dairies were found where the " milk room " was an open porch of the dairyman's residence (fig. 4), sometimes very disorderly and sometimes also the place where most of the domestic kitchen work is done, and in one case where hens were sitting. Milk receptacles will hardly be cleansed in a sanitary manner under such conditions, to say nothing of the exposure of the milk to impure air in straining and bottling.

DISTRIBUTION.

Most of the milk supply is retailed and distributed by the producers. Very little milk is transported by railroad in the South, and comparatively few cities have milk plants or depots owned by middlemen. Such establishments are found, however, in Macon, Atlanta, and Savannah, Ga.; Asheville, N. C.; Richmond, Va.; New Orleans, La.; Knoxville and Memphis, Tenn.; San Antonio, Fort Worth, and Austin, Tex.; and Fort Smith and Little Rock, Ark. Nearly all of the establishments in these cities pasteurize their entire output. Most of the milk is bought by the gallon, but some buy on a butterfat basis. In Savannah and Memphis the establishment of the plants grew largely out of a movement on the part of the producers to relieve themselves of the expense and trouble incident to doing a retail business. On account of climatic conditions two deliveries a day are frequent, milk often reaching the consumer less than five hours old. Bottles are used to a limited extent. (See Table 4.) The custom of dipping milk from the open can prevails somewhat, and in many

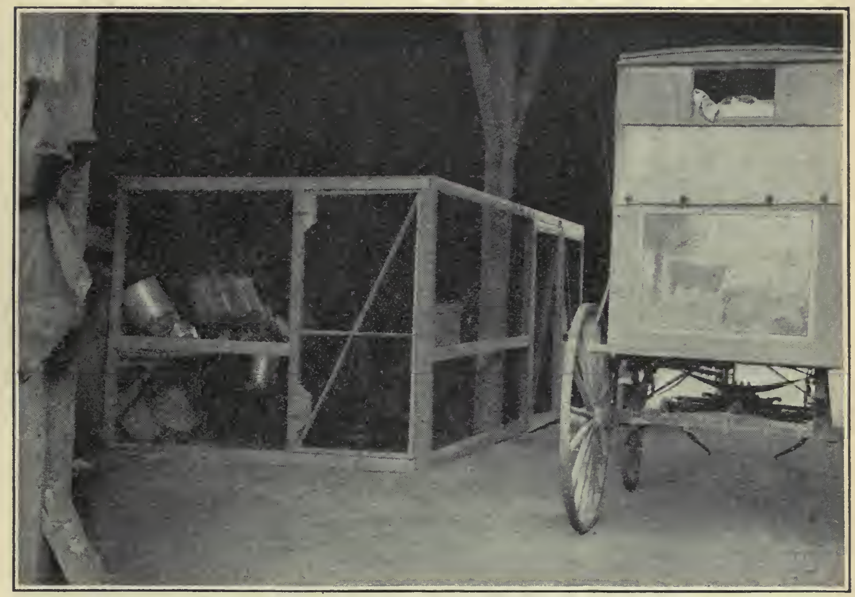

FIG. 3.—Milk room made by partitioning off with wire netting a corner of wagon house.

instances milk is drawn through faucets from large carriers. In a few cases the milk is poured from a two-gallon can provided with a cover which is also a measure, and in a few cities it is delivered in a varied assortment of tin cans and earthen jugs. Milk is usually delivered from wagons built especially for the business. In New Orleans high two-wheeled carts are used, the carrier faucet-cans being placed in the front part.

QUALITY.

The quality of the market milk is generally satisfactory so far as amount of milk solids is concerned. In many instances it is much above the legal requirement. The Memphis city chemist says that the milk supply of that city will average from 4.5 to 5 per cent of fat. Jersey blood is prominent among the dairy herds.

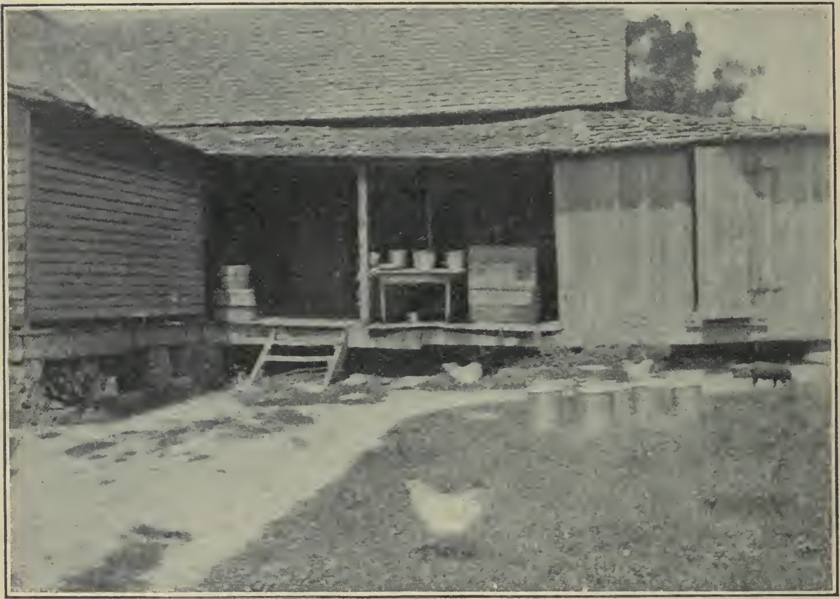

FIG. 4.—Porch of residence used as milk room; utensils drying and airing on lawn amid chickens and pigs.

As regards cleanliness and freedom from bacterial contamination the South has its share of the ignorance and negligence to which is due so much unsatisfactory market milk. In addition to this, some climatic and economic conditions have a peculiarly unfavorable bearing. Many producers are renters, doing a small business and struggling hard to make a living. Frequently they have poor barns and milk houses as well as inadequate facilities for handling the milk and washing the utensils. (See figs. 5 and 6.) In many cases the wife and children have to lend a hand in the dairy work. All these conditions are not only bad in themselves, but they have a tendency to crush any ambition to improve. The scarcity of ice prevents the proper cooling of much milk. Considerable quantities are therefore handled and sold at a high temperature, promoting rapid increase of bacteria.

A certified milk commission exists in Louisville, Ky.

PRICE, SUPPLY, AND DEMAND.

In many cities 10 cents a quart is the prevailing retail price of milk to the consumer. In some places only a few of the better dairies get 10 cents a quart, while many of the others take any price that is offered—as low as 5 cents a quart in a few instances. A common price is 6¼ cents a quart, 4 quarts for 25 cents.

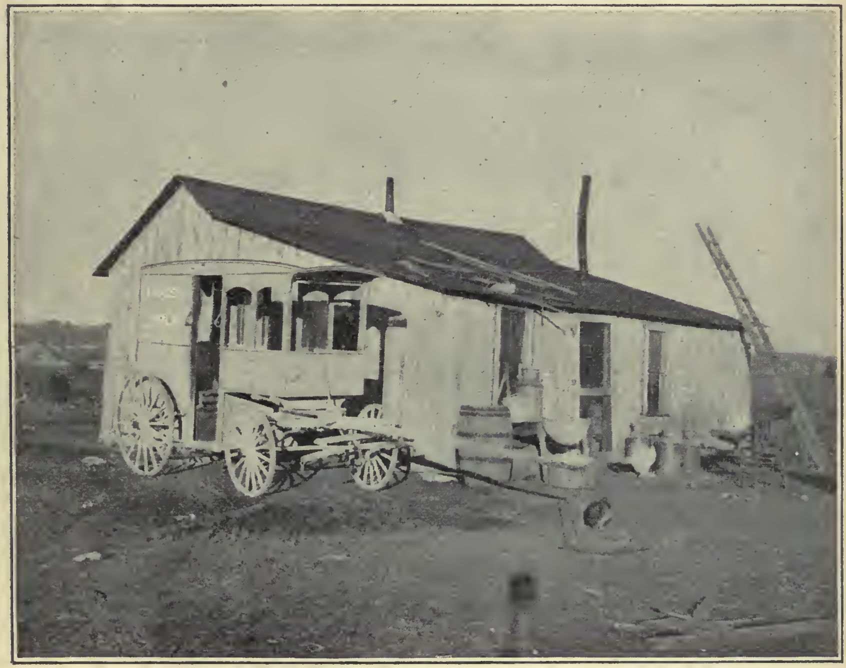

FIG. 5.—Residence of small dairyman containing milk room; milk cans exposed to chickens.

Generally speaking there is no oversupply, and in many places milk is actually scarce at times. In spite of this complaints are made of the competition in the business, chiefly among dairymen whose conditions are ordinary to poor. Prices are frequently cut where the ticket system prevails by giving a few extra tickets for a dollar. Twenty-eight pint tickets for $1 is a common price, which is about 7.2 cents per quart; but in some instances the thrifty housekeeper by skillful bargaining can get 30 or even 32 tickets, the dealer insisting that his price remains at 28 tickets and that the extra ones are a gift. Complaint is made in some places, notably Memphis, of uneven production, and of competition from small summer dairies in which the cows are milked for only such time as they can be kept on pasture. This "grass milk," cheaply produced, is sold at almost any price, and depresses the market for a few weeks each year, leaving some of the regular all-the-year dairies with a temporary surplus.

In some places there is a shortage, which compels the use of much condensed milk. Some of the large hotels are compelled to keep a stock of condensed milk on hand to be sure of an ample supply. In Florida complaints came to the writer from consumers concerning the inadequacy of the supply and the resultant independence of the milk producers and dealers. One Jacksonville business man with a "bottle baby" had milk delivered in the morning by one milkman and in the evening by another—double what he needed—to insure a supply should one or the other happen to omit his regular call.

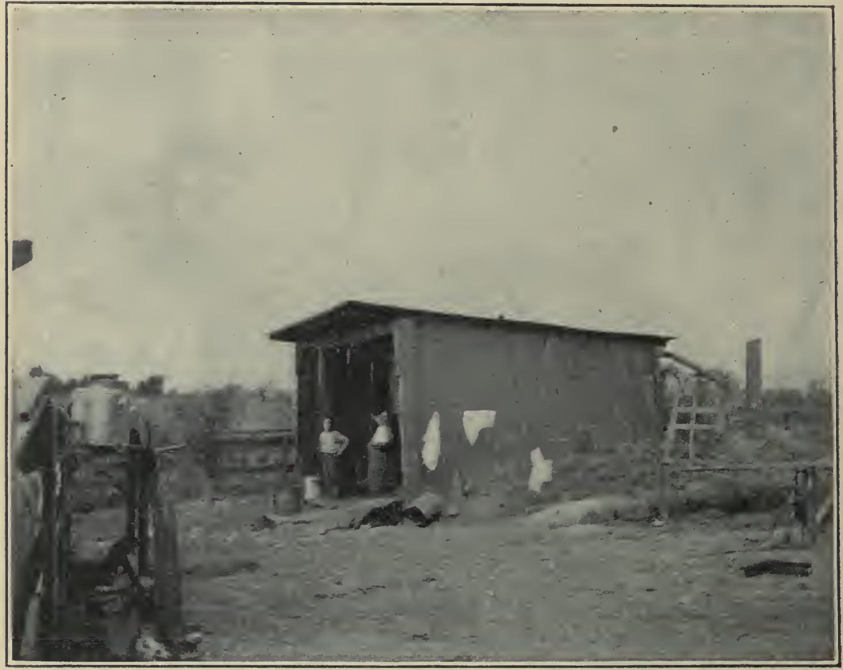

FIG. 6.—Milk house with one side open; work done by children.

INSPECTION.

Many cities have milk ordinances, though in not a few cases very little is done to enforce them. In some cities the collection of license fees and the issuance of permits for the sale of milk is the extent of milk inspection. Many cities had no inspection of any kind until a short time ago.

During the past year a campaign for better milk was taken up in Texas by a leading magazine. Representatives of the publication were sent to the seven largest cities of the State, and samples were taken of the milk as delivered by the dairymen. Thirty-five out of 53 samples, or 66 per cent, were found to contain preservatives. Some of the samples were also low in butterfat, indicating the addition of water or partial skimming. Within a few weeks after the publication of the magazine article showing these facts the municipal authorities in several of the cities began a warfare against adulterated milk.

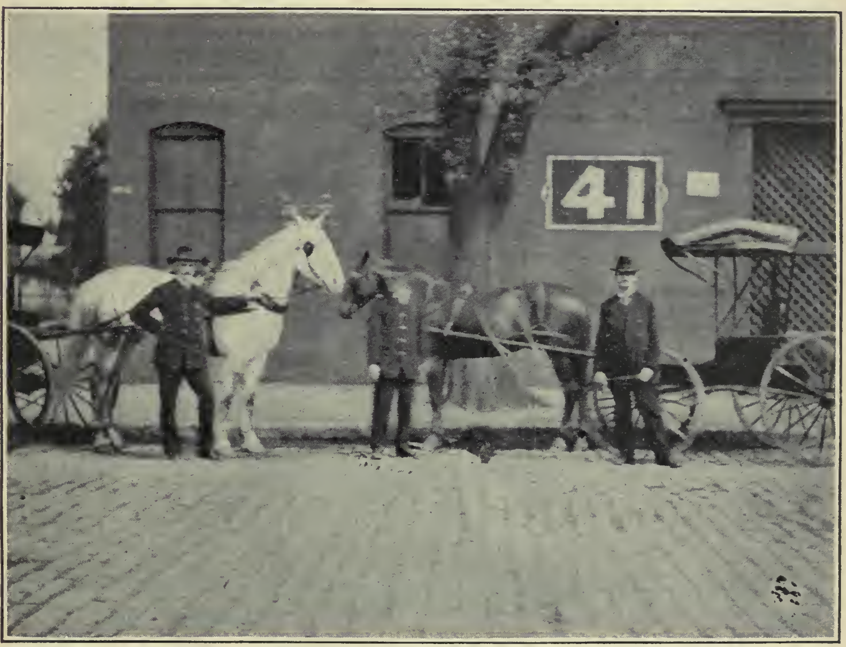

Fig. 7.—Uniformed milk-inspection corps, Atlanta, Ga.

Where ordinances have been in existence and have been enforced, the work under them has related largely to securing evidence of the sale of adulterated or under-standard milk, and in some places excellent work has been done along these lines, greatly improving the composition of the city supply. But in at least one city, where the custom of drawing milk from large cans prevails, samples are taken only from those carriers, and no effort is made to sample milk as delivered to the consumer, though it is a matter of common knowledge that this manner of distribution results in a very uneven product, many customers getting only skim milk.

The sanitary side of dairy inspection has received too little attention, but a gradual improvement in this direction is noticed. In Charleston, S. C., a code of laws was recently adopted and a milk inspector appointed. Considerable attention is given to the sanitary inspection of stables and methods of handling milk, with encouraging results. In Savannah, Ga., an outbreak of typhoid fever, traceable to a leading dairy, has called attention to the importance of supervising the milk supply, and an agitation for more inspection is under way. In Asheville, N. C., a milk inspector was recently appointed, and already there has been a radical cleaning up of some of the worst stables and an improvement in others. In Nashville and Memphis, Tenn., the county health officers have taken a new interest in the sanitary inspection of the dairies under their jurisdiction. Columbia, S. C., is agitating for milk ordinances and inspection. The Galveston, Tex., health office now gives a special certificate to all dairies whose apparatus, dairy rooms, and herds come up to a certain standard of cleanliness. Atlanta, Ga., has uniformed milk inspectors, who are furnished with buggies. (See fig. 7.) This city has recently adopted radical ordinances and greatly improved its milk supply. These ordinances, among other things, provide that—

> All milk shall be strained as soon as milked.
>
> All milk must be offered for sale as milked from the cows, and shall not be passed through cream separators or other apparatus other than strainers for the purpose of removing manure, dirt, or other substance.
>
> All milk shall be marketed as soon as possible after milking.
>
> It shall be unlawful for any person to bring or receive into the city of Atlanta, for sale, or to sell any milk which contains any manure or dirt (that is, in quantity sufficient to be detected with the naked eye after milk has been standing for one hour or more).

In Louisville, Ky., the activity of the State food inspection officials has succeeded in prohibiting the sale of milk from swill-fed dairies in that city. This war against milk from cows fed on distillery slops has had a good effect upon the milk supplies of the other cities of that State.

COST OF PRODUCTION.

Several factors tend to increase the cost of producing milk in the South. In the first place, but little attention seems to be given to keeping dairy cows which produce large amounts of milk, consequently few cows are kept which are large producers. In some instances Jersey blood predominates, but of families which are small producers. Many herds were found giving only about 5 quarts per day per animal. In other cases cows of the beef type are bought at the stock yards when about to freshen; these are milked through one period of lactation, then fattened, and sold for beef. Rarely does one find a herd of cows of dairy type selected or bred for the largest possible production of milk with 3.5 to 4 per cent fat.

Secondly, considerable work is done in an uneconomical manner. On account of the warm climate two deliveries per day are frequent, which means doubling this item of expense. The double time of man and team, and wear and tear of horse and wagon, must frequently more than offset the saving of ice, to say nothing of the inferior quality of the product. When milk is cooled in a spring the spring house is often at a distance from barn and residence, necessitating many additional steps and increasing the cost of production. The saving of steps seems to be an idea impossible for many persons to grasp.

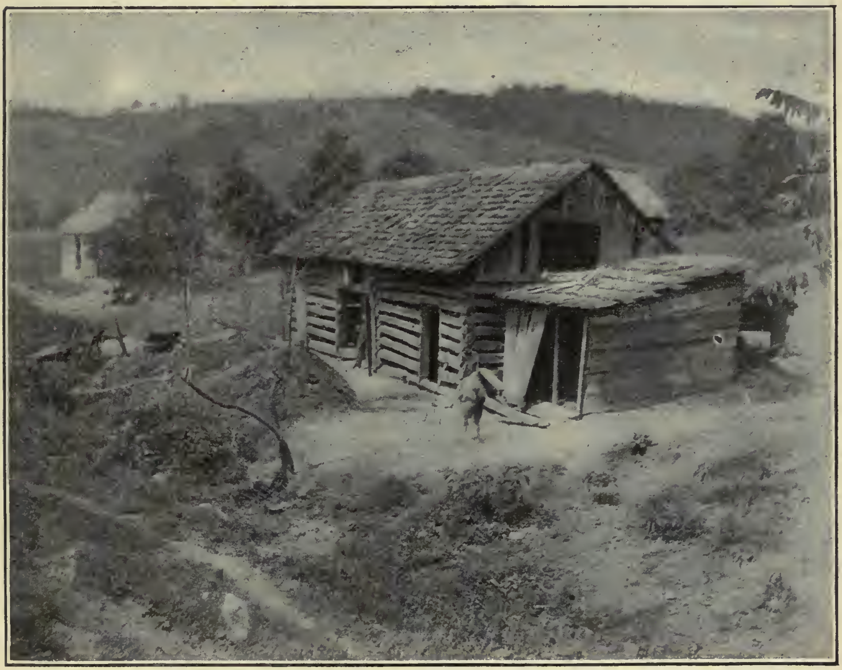

FIG. 8.—Stable affording inadequate protection to cows during inclement weather.

Thirdly, many southern dairy barns are unsuited for the most profitable production of milk on account of the fact that cows can not be kept comfortable in them at all times. In a country where much of the winter weather is mild the dairyman is apt to overlook the fact that even a brief chill to the delicate organism of a sensitive dairy cow damages the animal and shrinks the milk flow, which may be very expensive; the full flow of milk may not be regained for months. Consequently, where the temperature may drop as low as 40° F. even for only a few days in the year, or where damp chilly winds may bring discomfort to unprotected cows, even though for only a few hours, the stables should be so constructed as to protect the animals from the full force of the elements; otherwise the production is liable to drop in amount at almost any time. (See figs. 8 and 9.) Figure 10 illustrates a good type of southern barn which affords protection against inclement weather and at the same time provides light and ventilation.

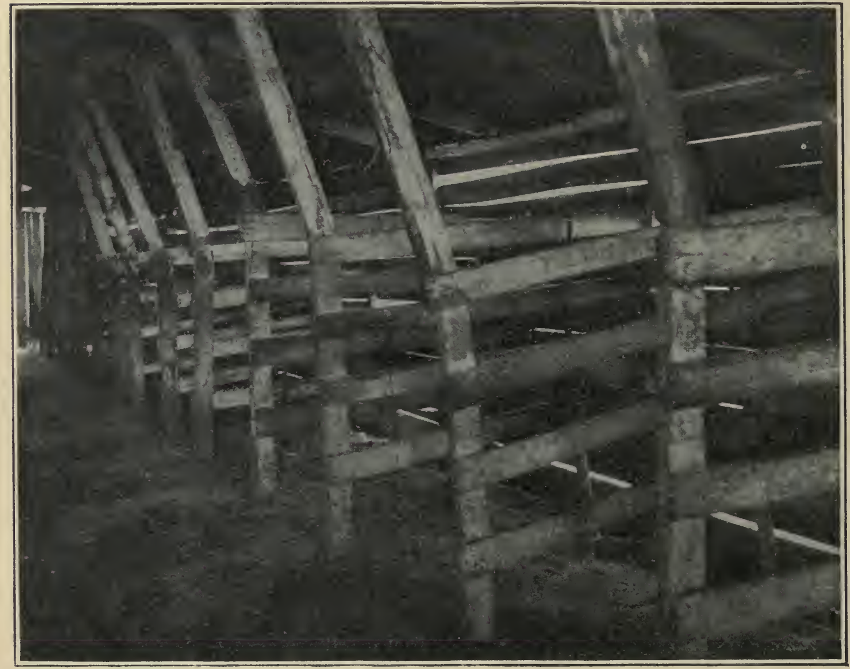

Fig. 9.—Interior of stable which does not protect cows against bad weather.

BUTTERMILK.

Large quantities of buttermilk are consumed in southern cities—Birmingham, Ala., being notable in this respect. It is everywhere popular as a beverage, and is always on the menus of hotels and restaurants; it is also used extensively in cooking, many families buying it by the gallon. The price ranges from 10 to 20 cents a gallon, 13 cents being about the average. In a number of places it is claimed that nearly as much buttermilk is consumed as whole milk, but exact figures as to the consumption of buttermilk can not be obtained.

Many buttermilk dealers have small dairies of 2 to 6 cows and go to market at irregular intervals with varying amounts of butter and buttermilk, and some cities do not require permits for the sale of buttermilk, hence there is much difficulty in determining the amount consumed.

Buttermilk dairying is popular with some producers, who claim that the income from the buttermilk and butter is almost as much as from whole sweet milk, without the necessity of daily delivery, the annoyance of inspection, and the expense of keeping the dairy up to the standard of cleanliness required for a sweet-milk dairy. But health officers are giving increased thought to buttermilk dairies, and doubtless in the near future a more careful buttermilk inspection will be demanded. Complaints of ptomaine poisoning alleged to have been due to buttermilk have come from Nashville, Tenn., and elsewhere.

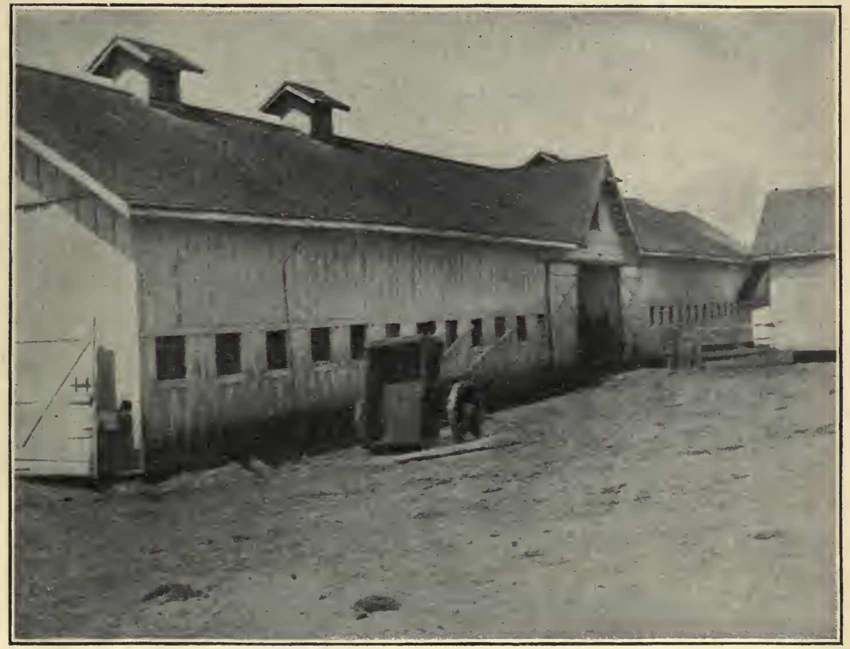

FIG. 10.—A good type of southern barn.

OPPORTUNITIES FOR IMPROVEMENT.

The southern market-milk situation is capable of much improvement. The dairymen can reduce the cost of production very materially by keeping cows better adapted for market-milk production, by studying economy of labor, and by using more cheap home-grown feeds suitable for milk production. Again the situation is capable of great development by an increased consumption. The per capita milk consumption in the South is below the average for the country. The per capita daily consumption of milk in the United States is estimated at about two-thirds of a pint; in Boston, Mass., it is eight-tenths of a pint; and as high as 1 pint is reported from some cities. On the other hand, in most southern cities the daily consumption is less than half a pint, and as low as one-third of a pint is named in some places. This showing may be somewhat misleading because of the large amount of buttermilk used, which doubtless takes the place of some sweet milk; but even if liberal allowance is made for this, the fact remains that the South consumes less than the average amount of milk. Moreover, the use of cream, of which large amounts are consumed in the North, is almost unknown in the South.

Several reasons for this low per capita consumption of milk and cream can be given: Indifference as to the food value of milk, an inherited habit of using milk in small quantities, an insufficient supply, suspicion of the purity of the product, and the large negro population. The latter consumes little or no milk, but materially increases the divisor to be used in ascertaining the per capita consumption. The last-named factor is, of course, purely sectional; but as regards the others, experience in different northern cities and towns has shown that an abundant supply of milk of unquestioned quality tends to increase the amount that is used; also that a campaign of education among producers helps consumption. Hence we may assume that when the milk supply of southern cities is improved by means of better sanitary inspection, and when the public realizes that an ample supply of clean, safe milk can be obtained, increasing amounts will be consumed.

Here is another opportunity for improving the condition of the southern dairyman. As the public is educated to realize the difference in the way good milk is produced as compared with the inferior article, there will be a willingness not only to consume more of that which is produced in the proper manner, but also to pay a higher price for it, as for a high-grade article. Already in Memphis and Nashville, Tenn., Asheville, N. C., and other places some dairies easily get 1 to 4 cents a quart more than others merely because the public has confidence that the product is pure and clean.

WHY DAIRYING IS UNDEVELOPED IN THE SOUTH.

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CONSUMPTION AND PRODUCTION.

The extent of the market for the various kinds of dairy products in the South has been shown in Table 4 (page 14), where data are given from 50 cities distributed throughout 13 States. The amounts of dairy products mentioned in Table 6, which are handled in these 50 cities, are far greater than the total amounts of those products produced in the 13 States in which the cities are located. The extent of production in these States and the difference between this home supply and the market demand are shown in the table below. · This table is a partial summary of Table 4, with some additional matter:

Table 6.—*Products handled in 50 southern cities, and estimated financial gain if produced at home.*

Product.	Quantity imported into 50 southern cities.	Amount produced in 13 Southern States.[a]	Average retail price.	Value of imported product.	Cows needed to supply deficiency.[b]	Cost of keeping cows at $45 a year.	Estimated profits that could be saved to the South.[c]
	Pounds.	*Pounds.*	*Cents.*	*Dollars.*	*Number.*	*Dollars.*	*Dollars.*
Creamery butter	23,434,941	890,768	33½	7,850,705	69,747	3,138,615	4,712,090
Renovated butter[d]	7,162,701	33,260	26	1,862,302	21,317	959,265	903,037
Cheese	41,582,545	782,000	20	8,316,509	69,304	3,118,680	5,197,829
Condensed milk[e]	42,560,688	....	10	4,256,069	14,187	638,415	3,617,654
Oleomargarin[f]	3,361,483	522,900	20	672,297	10,004	450,180	222,117
Total	....	....	....	22,957,882	184,559	8,305,155	14,652,727

[a] Census of 1905.
[b] Cows giving 6,000 pounds of milk or 336 pounds of butter.
[c] Cost of manufacture not deducted.
[d] Report of 39 cities.
[e] Report of 49 cities.
[f] Report of 40 cities; amount consumed in the 13 States, 6,766,221 pounds.

It will be noticed from the above table—

1. That the value of the dairy products shipped into these 50 cities (not including similar products that are shipped into other cities of those States) is $22,957,882, or an average of $459,157 per city.

2. That 184,559 cows, each giving 6,000 pounds of milk, or 336 pounds of butter, would be required to produce these products.

3. That after allowing $45 per cow for the cost of feed there would still remain, on the basis of retail prices given in Table 5, a profit of $14,652,727, or an average of $293,054 per city (cost of delivery not considered).

4. That 12,304 dairy farms, or an average of 246 farms per city, with 15 cows of the kind above named on each farm, would be required to supply these products.

5. That after allowing for the cost of the feed at the rate above given there would remain a profit of $1,191 per farm (the by-products of the dairy—calves, manure, skim milk, etc.—paying for the labor).

6. That each of these farms would require two men to operate it, hence giving profitable employment to 24,608 men, or an average of 492 men per city.

7. That since these dairies would greatly facilitate the growth of all kinds of crops, their development would tend to increase rather than decrease other agricultural products in that section.

There are hundreds of farmers throughout the South, each of whom could add a 15-cow dairy to his farm, and could besides in a short while easily produce more of other crops than he is producing at present.

WHY SOUTHERN DAIRYING IS UNPROFITABLE.

Dairying is undeveloped in the Southern States largely because the farmers of that section do not understand how to make it profitable. They realize the necessity of more fertilizer for their farms, and they are buying large quantities of it at high prices. They realize, too, that barnyard manure is superior to commercial fertilizer, but they do not understand how to keep the cattle to make the manure without sustaining a loss on the cattle.

This is due principally to three things: (1) The cattle now kept are, as a rule, inferior and could not be kept profitably under any circumstances; (2) many dairymen buy practically all their feed instead of growing it, especially those who live near the city and can get a good price for their products; and (3) the dairyman who lives some distance from the city and sells butter as a rule makes an inferior product. A very large per cent of the dairies in the Southern States are suffering from at least two of these difficulties and in many cases from all three.

Low Average Production Per Cow.

In the 13 States named in Table 4 the average cow, according to the census of 1900, produces annually only 3,036 pounds of milk, which it is estimated will average 4.8 per cent of butterfat, and will therefore make 145.7 pounds of butterfat, or about 170 pounds of butter. In the following two tables the returns from this average cow are compared with the returns from a good cow. The standard adopted for the good cow—6,000 pounds of milk, making 288 pounds of butterfat—is reasonable, since in some herds in the South each cow in the herd has exceeded it in her average.

The tables show the average amount received under each of the three methods of marketing commonly used in that section. The prices given are averaged from Table 5.

TABLE 7.—*Estimated net returns from an average southern cow in one year under three methods of marketing.*

Method of marketing.	Milk produced.	Average price.	Amount received.	Cost of feed.	Net returns.
	Gallons.				
1. Producer sells whole milk retail	353	8.6 cents per quart	$121.43	$40	[a]$46.13
2. Producer sells whole milk to dealer.	353	17 cents per gallon	60.01	40	20.01
3. Producer sells dairy butter—[b]					
145.7 pounds butterfat making 170 pounds butter.		25.8 cents per pound	43.86		
Leaving 2,890 pounds skim milk.		20 cents per 100 lbs.[c]	5.78		
Total receipts from butter making.			49.64	40	9.64

[a] After deducting $35.30 for cost of delivery at 10 cents a gallon.
[b] Using 4.8 per cent as fat test.
[c] Estimated value for feeding purposes.

TABLE 8.—*Estimated net returns from a good cow in one year under same three methods of marketing given in Table 7.*

Method of marketing.	Milk produced.	Average price.	Amount received.	Cost of feed.	Net returns.
	Gallons.				
1. Producer sells whole milk retail	[a]698	8.6 cents per quart	$240.11	$45	[b]$125.31
2. Producer sells whole milk to dealer.	698	17 cents per gallon	118.66	45	73.66
3. Producer sells dairy butter—[c]					
288 pounds butterfat making 336 pounds butter.		25.8 cents per pound	86.69		
Leaving 5,712 pounds skim milk.		20 cents per 100 lbs.[d]	11.42		
Total receipts from butter making.			98.11	45	53.11

[a] Six thousand pounds, or 698 gallons.
[b] After deducting $69.80 for cost of delivery at 10 cents per gallon.
[c] Using 4.8 per cent as fat test.
[d] Estimated value for feeding purposes.

Dairying is to a large extent restricted to an area around the cities. Table 7, which represents actual conditions, will show the cause of this fact. The average cow in a dairy herd located so that the milk can be delivered direct to the consumer earns $46.13 a year, after paying for feed and delivery; if this cow's milk is made into butter she earns $9.64 after paying for feed (no allowance being made for farm labor in either case). From these facts the average dairyman would decide that supplying retail milk is the more profitable. As a matter of fact there is little profit in either one. The man who is retailing milk often has no farm, therefore has no use for manure and does not take care of it, and being located near the city labor is more expensive. The man who sells butter perhaps has a farm, and therefore his feed may cost less than $40 per cow; then, too, if he clears nothing more than the manure, this may enable him to make his farm very profitable for other things; such cases are not uncommon.

In cases where milk is sold wholesale (2, Table 7) it would appear that some advantages exist. In such cases the dairymen usually own farms, and a few of them have made money. Still there are disadvantages to be contended with. The profit is greater than in butter making (3, Table 7), but no allowance is made for expense of shipping, there is no skim milk, and on the whole perhaps no more can be said for this class than for the other two. They are all to a large extent failures.

Different Results with High-Class Dairy Cows.

Where, then, are the successful dairies found? They are in the classes represented in Table 8. In this table each of the classes has an excellent showing for a profit, if reasonably good business methods are used.

In comparing Table 8 with Table 7 it will be seen that in the former $45 is allowed for the cost of feed, as against $40 in Table 7. If the methods used in both cases were the same the difference should perhaps be greater; in other words, $40 would probably be more than is necessary to feed the average cow. But it is safe to assume that such is not the case, because the man who does not know enough to keep cows that are above the average, as a rule, does not know enough to feed them most economically.

In continuing this comparison it will be noted: (1) That after allowing for feed and delivery there remains from the retailing of the milk $125.31 in the case of the good cow, as against $46.13 for the average cow; (2) that after allowing for feed there remains from the wholesaling of the milk $73.66 in the case of the good cow, as against $20.01 for the average cow; and (3) that after allowing for feed and adding the value of the skim milk there remains from the sale of the butter $53.11 in favor of the good cow, as against $9.64 for the average cow.

The question that naturally arises from a comparison of Tables 7 and 8 is, Why will any man keep such cattle as are represented in Table 7 when he can make so much more profit with better cattle, as shown in Table 8? There can be no answer other than that it is because of a lack of knowledge. According to the census of 1900 there were 4,097,961 cows in the States named in Table 4. These cows were annually producing 1,444,291,536 gallons of milk, or 596,203,546 pounds of butterfat. If these cattle were of the class shown in Table 8, they would produce 2,859,042,558 gallons of milk, or 1,180,212,768 pounds of butterfat; an increase of 1,414,751,022 gallons of milk, or 584,009,222 pounds of butterfat. Valuing this milk at the average wholesale price given in Table 5, this increase would be worth $240,507,674; or valuing the butterfat in this milk according to the wholesale rate in the table it would be worth $175,785,776.

In other words, the dairymen are annually losing not less than $175,786,776 because they are keeping cows that produce an average of 353 gallons of milk per annum instead of cows that will produce 698 gallons, or 6,000 pounds, per annum. This is too important an item for the dairyman to overlook; and it is certainly one of the most important causes of the present undeveloped condition of the dairy industry in the Southern States.

HOW TO GET GOOD COWS.

In considering this question, the source whence dairy cattle are obtained is of paramount consideration. It is true that the southern dairies are to a large extent in the vicinities of the cities, therefore, as has previously been shown, it is more profitable for them to sell whole milk. Skim milk as well as the facilities of the farm are lacking, consequently the raising of calves becomes a difficult and expensive operation. As a result the majority of such dairymen rely entirely on the market for their supply of cattle. In the interior country districts there is usually very little dairying, hence the supply of dairy cattle in those districts is very limited. The stock yard therefore becomes the only source of supply of cattle for a very large proportion of the dairies. Cows that are in milk are purchased, and when they go dry they are again sent to the stock yard. This practice is one of the essential causes of the low average milk production of southern cattle.

But in addition to this practice, those who do raise dairy cattle usually breed their cows to inferior, scrub, or grade bulls, and ignore the performances of the individual cows. These customs will surely prevent any marked improvement of the herd. Three things are recognized as essential by all successful breeders of dairy cattle: (1) Systematic records should be kept of all cows so as to determine which are profitable; (2) a purebred bull, well selected, should be used; and (3) the heifer calves from the best cows only should be retained in the herd. Some of these heifers will prove to be inferior individuals, and should be disposed of; but if the system is consistently carried out it will produce gradual improvement in the herd, regardless of what grade of cattle was used to begin with.

But even this does not solve the problem for the man who has neither farm facilities nor skim milk with which to raise calves. What, therefore, can he do? First, under average conditions, he should either buy a farm or get out of the dairy business. This is particularly true of the Southern States, where so much feed can be produced at a comparatively small cost, and where good pastures can be maintained for a great part of the year. But when the farm has been procured, how will the skim milk be obtained which is so essential in raising calves? This is an important consideration, and can often be provided for in the following manner:

There is a great demand for sweet cream throughout the South, which is often either supplied from the North or remains unsupplied. As it commands a very good price, very often such cream will bring as much as the whole milk from which it was taken. Therefore a whole-milk business can often be converted into a sweet-cream business without reducing the income from sales, and thus the skim milk can be retained at little or no cost. Sometimes it may be best to separate the cream from only enough of the milk to provide a sufficient supply of skim milk for the calves, and then sell this cream to the same customers who buy the whole milk. Even if a small loss in the sales is at first sustained by this system, it must be remembered that good cows are absolutely essential to a profitable dairy and that the increased production which will result from this system will soon offset any loss that was sustained at first in putting it into practice.

FEEDING.

In order that cattle may produce the most milk and do it most economically, they must have suitable feed, not all of which can be obtained by buying on the market. Green feed is very essential, and when it is not available direct from the field it should be supplied in the form of silage. It is impracticable to go into a discussion of feed in this paper, but too much emphasis can not be given to the matter of preparing the right kind of feed. In many cases the cows are fed on nothing but cotton-seed meal and hulls. This is not only an expensive feed, but it is entirely insufficient to give the best results. When used in combination with silage and good hay, cotton-seed meal particularly can be used to good advantage. Another very bad practice in connection with feeding is that the cattle are often not fed enough. Many a good cow is producing far less than her maximum because of an insufficient amount of feed.

As mentioned elsewhere, the inclination of the dairyman to rely entirely upon the market for his supply of feed is a very great drawback to the dairy industry of the South, and is a bad practice in two ways: (1) It is impossible to supply entirely from the market the kind of feed that is best for the cows, and (2) even if a suitable feed could be obtained from the market, it would be more expensive than if grown on the farm. All rough feed, at any rate, and in some cases a part of the grain, can be grown to great advantage. With the great variety of forage crops, particularly legumes, that are available under southern conditions, the production of feed is neither difficult nor expensive, and yet in this section the dairymen are producing less feed than in almost any other part of the United States. The southern dairyman can never fully succeed until he produces more of his feed.

Pastures can be made that will furnish good grazing for the greater part of the year. There are two reasons why pastures should be used liberally, namely, the long pasture season, and the cheap lands; yet comparatively few southern dairymen have proper pastures. The waste lands of the farms that are covered with ditches and pine saplings are often fenced, but no further improvement is made; such pastures are little better than useless.

INFERIOR BUTTER.

There is in the South a large amount of butter sold to the renovated-butter factories as packing stock. This as a rule does not come from the dairies, but much of the dairy output also would be thus sold if the butter market were as discriminating as it is in some sections. The above-mentioned packing stock is what is commonly called "country butter," and comes from farms where one or two cows are kept for family use, the surplus butter being sold to a near-by grocery store. The stores are compelled to purchase such butter to retain the trade of those who sell the butter. Often the stores can retail this butter at once to other customers, but what can not be disposed of in this way is packed in barrels and when a sufficient amount has accumulated it is shipped to some renovating factory. Thus it is that this country butter often sells for from 7 to 15 cents a pound when good butter is retailing at an average price of 33½ cents per pound (1907 prices). This discrimination on the part of the consumer is not against the producer, but instead is against an inferior article which the consumer will not accept, and which must, therefore, be sold as packing stock. This may seem like a very small item to the individual farmer who is producing such butter, but the practice is costing the farmers of the South in the aggregate an immense sum of money annually. The remedy for this practice is for those who are producing such butter to study the subject of butter making until a good article can be made. It is often true also that those who are producing packing stock are of the opinion that this butter is as good as can be made and that there is some other cause of such discrimination against their product. Every farmer who is conducting his work in a business-like manner must look after such details.

In Tables 7 and 8 butter production is shown to be the least profitable of the three kinds of dairying mentioned. But since this kind of dairying can be done anywhere, irrespective of the location of the market, it is by far the most important branch of the dairying of the South. When properly conducted it can be made very profitable, and there are a number of examples in various places that prove this. On these farms a dairy house suitably equipped for making butter on a small scale is provided at little cost, and when the proper methods are used excellent results are obtained. A small number of such plants are producing butter that always sells for the highest market price. When results are not satisfactory it is usually found that bad methods are practiced. It is hoped that the better kind of dairying will grow more in favor with the southern farmers.

HIGHER PRICES FOR BETTER MILK.

In the preceding article it is shown that the sanitary conditions surrounding the milk supply of many cities in the South are bad; hence dangerous milk is the result. There is now a great movement in progress throughout the whole country to improve the milk supply. To accomplish this it is often considered necessary that a higher price be paid for a better quality of milk, because the cost of producing it is greater. While this is generally the case, it is notably true that in some cities where prices are highest the quality of the milk is poorest.

It is also true that very unprofitable dairies often get the same price for their product as very profitable ones that are operating under exactly the same natural conditions. While quality in milk must be appreciated by the consumer and paid for, still there is usually something needed in addition to higher prices.

SUMMARY.

Some of the improvements which the situation demands have been suggested in the foregoing pages, and these are briefly reviewed in the following summary:

1. There is no branch of agriculture that is more needed in the South than dairying. It is not only a profitable industry in itself, but it may be made the means of increasing the productiveness of the soil and promoting a better type of agriculture.

2. It is found that southern dairymen, as a rule, are not using the most economic methods in the following particulars: (*a*) The production of the average cow is only about half what it should be. (*b*) Too many of the dairies are in the cities, when they should be on the farms; hence too high-priced feed and bad methods of feeding. (*c*) Milk and butter of poor quality are produced, which do not bring the highest prices.

3. It is strikingly true that in most cases where an inferior dairy herd has been in existence for some years it will be found that expensive methods are being practiced and an inferior grade of output is being produced.

4. Southern dairying needs improvement all along the line. The cost of production is unreasonably high, the sanitary conditions are often bad, and the price of first-class products is in some cases too low.

5. The three main points that every southern dairyman should bear in mind, and which can not be too strongly emphasized, are—

Better cows.
More home-grown feed.
A better product.

FARMERS' BULLETINS.

The following is a list, by number, of the Farmers' Bulletins available for distribution. The bulletins entitled "Experiment Station Work" give in brief the results of experiments performed by the State experiment stations. Titles of other bulletins are self-explanatory. Bulletins in this list will be sent free to any address in the United States on application to a Senator, Representative, or Delegate in Congress, or to the Secretary of Agriculture, Washington, D. C. Numbers omitted have been discontinued, being superseded by later bulletins.

22. The Feeding of Farm Animals. Pp. 40.
24. Hog Cholera and Swine Plague. Pp. 16.
27. Flax for Seed and Fiber. Pp. 16.
28. Weeds; and How to Kill Them. Pp. 30.
30. Grape Diseases on the Pacific Coast. Pp. 15.
32. Silos and Silage. Pp. 30.
33. Peach Growing for Market. Pp. 24.
34. Meats: Composition and Cooking. Pp. 31.
35. Potato Culture. Pp. 24.
36. Cotton Seed and Its Products. Pp. 16.
42. Facts About Milk. Pp. 32.
44. Commercial Fertilizers. Pp. 38.
47. Insects Affecting the Cotton Plant. Pp. 32.
48. The Manuring of Cotton. Pp. 16.
49. Sheep Feeding. Pp. 24.
51. Standard Varieties of Chickens. Pp. 48.
52. The Sugar Beet. Pp. 48.
54. Some Common Birds. Pp. 48.
55. The Dairy Herd. Pp. 30.
56. Experiment Station Work—I. Pp. 30.
58. The Soy Bean as a Forage Crop. Pp. 24.
59. Bee Keeping. Pp. 48.
60. Methods of Curing Tobacco. Pp. 24.
61. Asparagus Culture. Pp. 40.
62. Marketing Farm Produce. Pp. 31.
63. Care of Milk on the Farm. Pp. 40.
64. Ducks and Geese. Pp. 55.
65. Experiment Station Work—II. Pp. 32.
66. Meadows and Pastures. Pp. 30.
69. Experiment Station Work—III. Pp. 32.
71. Essentials in Beef Production. Pp. 24.
73. Experiment Station Work—IV. Pp. 32.
74. Milk as Food. Pp. 39.
77. The Liming of Soils. Pp. 24.
78. Experiment Station Work—V. Pp. 32.
79. Experiment Station Work—VI. Pp. 27.
80. The Peach Twig-Borer. Pp. 16.
81. Corn Culture in the South. Pp. 24.
82. The Culture of Tobacco. Pp. 22.
83. Tobacco Soils. Pp. 23.
84. Experiment Station Work—VII. Pp. 32.
85. Fish as Food. Pp. 32.
86. Thirty Poisonous Plants. Pp. 32.
87. Experiment Station Work—VIII. Pp. 32.
88. Alkali Lands. Pp. 23.
91. Potato Diseases and Treatment. Pp. 15.
92. Experiment Station Work—IX. Pp. 30.
93. Sugar as Food. Pp. 31.
96. Raising Sheep for Mutton. Pp. 48.
97. Experiment Station Work—X. Pp. 32.
98. Suggestions to Southern Farmers. Pp. 48.
99. Insect Enemies of Shade Trees. Pp. 30.
100. Hog Raising in the South. Pp. 40.
101. Millets. Pp. 30.
102. Southern Forage Plants. Pp. 48.
103. Experiment Station Work—XI. Pp. 30.
104. Notes on Frost. Pp. 31.
105. Experiment Station Work—XII. Pp. 32.
106. Breeds of Dairy Cattle. Pp. 48.
107. Experiment Station Work—XIII. Pp. 32.
110. Rice Culture in the United States. Pp. 28.
112. Bread and Bread Making. Pp. 40.
113. The Apple and How to Grow It. Pp. 32.
114. Experiment Station Work—XIV. Pp. 28.
116. Irrigation in Fruit Growing. Pp. 48.
118. Grape Growing in the South. Pp. 32.
119. Experiment Station Work—XV. Pp. 30.
120. Insects Affecting Tobacco. Pp. 32.
121. Beans, Peas, and Other Legumes as Food. Pp. 38.
122. Experiment Station Work—XVI. Pp. 32.
124. Experiment Station Work—XVII. Pp. 32.
125. Protection of Food Products from Injurious Temperatures. Pp. 24.
126. Practical Suggestions for Farm Buildings. Pp. 48.
127. Important Insecticides. Pp. 46.
128. Eggs and Their Uses as Food. Pp. 40.
131. Household Tests for Detection of Oleomargarine and Renovated Butter. Pp. 10.
132. Insect Enemies of Growing Wheat. Pp. 38.
133. Experiment Station Work—XVIII. Pp. 32.
134. Tree Planting in Rural School Grounds. Pp. 32.
135. Sorghum Sirup Manufacture. Pp. 40.
137. The Angora Goat. Pp. 48.
138. Irrigation in Field and Garden. Pp. 40.
139. Emmer: A Grain for the Semiarid Regions. Pp. 16.
140. Pineapple Growing. Pp. 48.
142. Principles of Nutrition and Nutritive Value of Food. Pp. 48.
144. Experiment Station Work—XIX. Pp. 32.
145. Carbon Bisulphid as an Insecticide. Pp. 28.
147. Winter Forage Crops for the South. Pp. 40.
149. Experiment Station Work—XX. Pp. 32.
150. Clearing New Land. Pp. 24.
152. Scabies of Cattle. Pp. 32.
154. The Home Fruit Garden: Preparation and Care. Pp. 16.
155. How Insects Affect Health in Rural Districts. Pp. 19.
156. The Home Vineyard. Pp. 22.
157. The Propagation of Plants. Pp. 24.
158. How to Build Small Irrigation Ditches. Pp. 28.
159. Scab in Sheep. Pp. 48.
161. Practical Suggestions for Fruit Growers. Pp. 30.
162. Experiment Station Work—XXI. Pp. 32.
164. Rape as a Forage Crop. Pp. 16.
165. Silkworm Culture. Pp. 32.
166. Cheese Making on the Farm. Pp. 16.
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169. Experiment Station Work—XXII. Pp. 32.
170. Principles of Horse Feeding. Pp. 44.
172. Scale Insects and Mites on Citrus Trees. Pp. 43.
173. Primer of Forestry. Pp. 48.
174. Broom Corn. Pp. 30.
175. Home Manufacture and Use of Unfermented Grape Juice. Pp. 16.
176. Cranberry Culture. Pp. 20.
177. Squab Raising. Pp. 32.
178. Insects Injurious in Cranberry Culture. Pp. 32.
179. Horseshoeing. Pp. 30.
181. Pruning. Pp. 39.
182. Poultry as Food. Pp. 40.
183. Meat on the Farm: Butchering, Curing, and Keeping. Pp. 37.
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186. Experiment Station Work—XXIII. Pp. 32.
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190. Experiment Station Work—XXIV. Pp. 32.
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194. Alfalfa Seed. Pp. 14.
195. Annual Flowering Plants. Pp. 48.
196. Usefulness of the American Toad. Pp. 16.
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199. Corn Growing. Pp. 32.
200. Turkeys. Pp. 40.
201. Cream Separator on Western Farms. Pp. 23.
202. Experiment Station Work—XXVI. Pp. 32.
203. Canned Fruits, Preserves, and Jellies. Pp. 32.
204. The Cultivation of Mushrooms. Pp. 24.
205. Pig Management. Pp. 45.
206. Milk Fever and Its Treatment. Pp. 16.

209. Controlling the Boll Weevil in Cotton Seed and at Ginneries. Pp. 32.
210. Experiment Station Work—XXVII. Pp. 32.
211. The Use of Paris Green in Controlling the Cotton Boll Weevil. Pp. 23.
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FARMERS' BULLETIN 350.

THE DEHORNING OF CATTLE.

BY

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Bureau of Animal Industry.

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1909.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Animal Industry,
Washington, D. C., December 9, 1908.

Sir: I have the honor to transmit herewith a paper on "The Dehorning of Cattle," by Dr. Richard W. Hickman, chief of the Quarantine Division of this Bureau. This article was included in the Twenty-fourth Annual Report of the Bureau, but in order to make it available for distribution in pamphlet form, in response to requests for information on this subject, its publication as a Farmers' Bulletin is recommended.

Respectfully,

A. D. Melvin,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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THE DEHORNING OF CATTLE.

SIMPLE METHOD OF RESTRAINING THE ANIMALS.

The dehorning of cattle can be very satisfactorily performed without other apparatus or instruments than a good strong clothesline and a clean sharp meat saw, or a miter saw with a rigid back. The same simple means for controlling the animal is just as applicable when dehorning clippers are to be used as when the horns are to be removed with the saw. The head of the animal is secured to the horizontal rail or stringer which holds the upper ends of the stanchion boards. The animal is put in the stanchion in the usual manner; then one end of a heavy clothesline is passed around the upper part of the neck and tied in a knot that will not slip, otherwise it will choke the animal. The free end of the rope is now carried between the horns, through the stanchion to the front, up and over the horizontal stanchion rail, then down underneath the neck and up and over the top of the stanchion rail to an assistant, who should hold it firmly. Now open the stanchion, allowing the animal to withdraw its head; then, keeping the rope tight, pass it once around the muzzle, up and over the stanchion rail, and through to the front again to the hands of the assistant, who should stand 3 or 4 feet in front of the animal and hold the rope firmly, but prepared to release it when told to do so by the operator. The animal is now ready for the dehorning operation.

It is necessary that the rope be held by an assistant, as in the event of the animal struggling during the operation so as to throw itself off its feet, or if there appears to be danger of its choking, the rope may be slackened promptly at the word of the operator and the animal partly released. This, however, is rarely necessary, for as soon as the head is secured the operator should be ready, standing at the right shoulder of the animal with his saw, and proceed to saw off first the right and then the left horn. Figure 1 shows the animal and the operator in position for the dehorning operation by this method. It is a good plan before commencing the real work to experiment upon an animal in the matter of control by tying the head to the stanchion rail as described.

If the stanchion rail is too wide to permit of properly securing the lower part as well as the upper part of the animal's head, the turn of the rope around the muzzle may be omitted and the last lap of the rope carried around the stanchion rail to the front and to the hands of the assistant. Care should be taken that the rope pass each time over the neck of the animal to the stanchion rail between the horns in such a way that it will not interfere with the work of the saw.

WHERE TO CUT THE HORNS.

The horns should be severed from a quarter to a half inch below where the skin joins the base of the horn, cutting from the back toward the front.

If the cut is made too high an irregular, gnarly growth of horn is very apt to follow. It will be seen that the point of union of the skin and horn varies in different cattle; hence there can be no rule of measurement, except as the eye becomes trained to see the point or line at which the cut should be made. In the beef breeds fully one-half inch of skin, all around, is usually taken off with the horn.

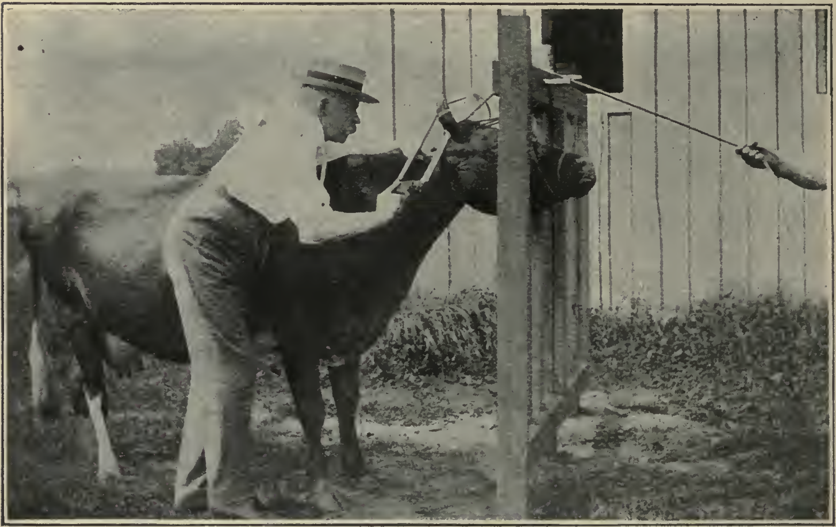

Fig. 1.—Method of tying cow to stanchion rail.

Figure 2 illustrates the difference between a proper and an improper cutting, and figures 3 and 4 show the appearance of animals' heads after proper and improper dehorning.

INSTRUMENTS FOR DEHORNING.

In recent years, since dehorning shears or clippers have come into use, this means of dehorning is considered by some cattle owners to be preferable, especially where large numbers of cattle are to be dehorned. One type of dehorner has a stationary knife blade, with its cutting edge shaped like a very wide V, and opposing this another knife of similar shape, moving in a slide, so that the cutting edges cut the horn from all four sides at once, all the edges passing the center at the same time. Another type has a movable knife with one oblique or one curved edge, and the cutting is done in one direction only. The power for cutting with these instruments is supplied by pulling together two long handles, which, in order to transmit a greater force, are generally so constructed that they act through the medium of a series of cogs.

In dehorning with these instruments the opening between the cutting edges should be slipped down over the horn and the knives closed so that their edges set firmly against the horn in such a position that the cut will be made in the right place and in the right direction. The blades should be kept covered with a thick oil or grease. The handles should be drawn together with a quick, firm, strong pull, so that the horn will be completely severed by the first act and without twisting. Care should be taken to keep the blades sharpened on their original bevel.

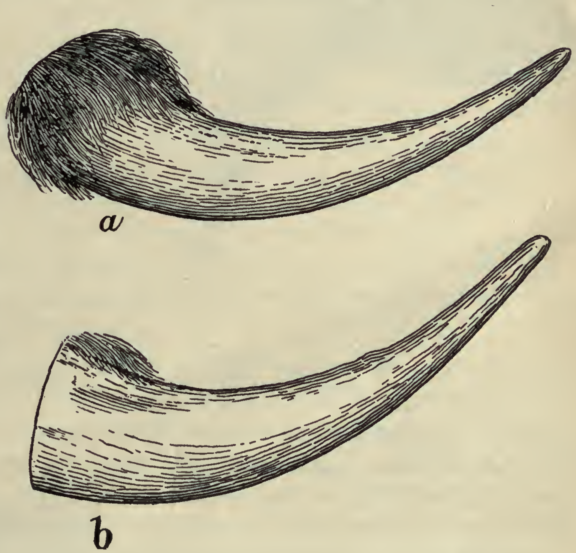

Fig. 2.—Horns showing (*a*) proper and (*b*) improper cutting.

Dehorning instruments can be procured of the manufacturers and of dealers in veterinary instruments.

In dairy districts adjacent to large cities there are men who go about from farm to farm dehorning animals, charging for their services in some instances as little as 5 cents per horn or 10 cents per animal.

There was published in the report of the New Zealand department of agriculture for 1904 a description of the operation of dehorning cattle by the government veterinarian at New Plymouth, in which it was shown that a cage had been used for the restraint of the animals during the operation, closely resembling the box used for hoisting horses out of ships, this cage being hauled on a wagon from farm to farm as needed. In discussing the various means for the removal of the horns the report was very favorable to the use of the saw in dehorning full-grown cattle. It was stated that in the dehorning of over 10,000 cows with the saw there were no deaths due to the operation, while in cows dehorned by shears there was trouble afterwards in healing of the wounds, due, no doubt, to the crushing, fracturing action which this instrument has upon old horns, where ossification of the cores is advanced. Because of this condition it was recommended that for mature animals a bone saw be used.

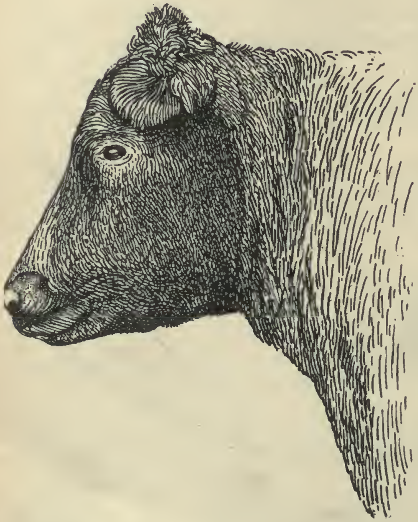

FIG. 3.—Head of steer showing result of proper dehorning.

TREATMENT AFTER DEHORNING.

It is not usual to apply any preparation after the operation of dehorning to prevent bleeding, as the loss of blood is not sufficient, as a rule, to be of consequence. Care should be taken, however, to prevent substances from getting into the openings left after the horns are removed. The horn cores are elongations of the frontal bones of the skull, and are hollow. They communicate with the frontal sinuses, or air spaces, of the head; therefore foreign substances or fragments of horn which act as an irritant in these cavities are apt to set up an inflammation, resulting in the formation of pus or an abscess, which may prove quite serious. This trouble is of infrequent occurrence, but would appear more liable to happen when the dehorning instruments are used, on account of their tendency to crush, especially in the case of old animals, whereas the saw cuts clean. If proper care is taken, however, such an occurrence following dehorning may in almost every instance be avoided.

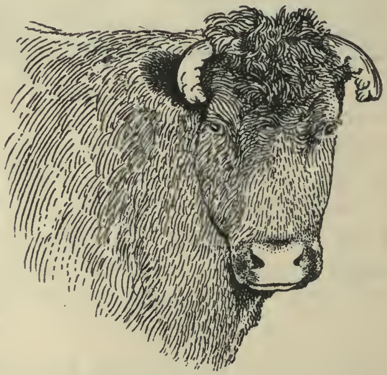

FIG. 4.—Head of steer showing results of improper dehorning.

Occasionally animals after being dehorned and turned out of the stable will rub their heads against a dirt or gravel bank or the rough bark of a tree, and foreign material may thus get into the cavities, though usually the soreness of the parts is sufficient to prevent this.

If the animals are dehorned in warm weather, it is well to apply some pine tar with a view to keeping flies from the wounds. Some operators do this in nearly all cases, thinking that it facilitates healing. The dehorning operation should always, when possible, be performed in cool weather, and upon animals which have at least attained the age of two years.

IS DEHORNING CRUEL?

Inquiries are frequently received as to whether the operation of dehorning is very painful, and whether it may not be classed as cruelty to animals. Those who have had an extensive experience in dehorning appear to agree that the pain induced by the operation has been greatly overestimated, as careful observation has shown that shrinkage in the yield of milk as well as of butterfat following the dehorning of cows is very temporary and insignificant. On the other hand, the worry, pain, and cruelty often inflicted by cattle upon their mates before being deprived of their horns is much more to be considered, and not infrequently results in the death of a valuable animal. A neighbor on an adjoining farm to that owned by the writer a few years ago lost two good milch cows in one winter through their being disemboweled by the horns of barnyard mates while out for exercise. He dehorned his entire herd almost immediately afterwards. The increased safety of the animals much more than compensates for any loss of beauty resulting from the removal of horns.

DEHORNING ON THE RANGE.

While the cattle ranchman of the West seems to be equal to every requirement and emergency of his vocation, and is probably informed with regard to the dehorning of his stock, this article would be incomplete without a description of the dehorning operation as practiced in that part of the country.

In the range country of the West dehorning has been extensively practiced for a number of years, and various methods have been used in restraining the animals, as well as in removing their horns. In some instances the methods used are extremely crude, consisting in simply roping and throwing the animal and cutting off the horns with an ax. Most frequently, however, no matter what may be the means of control, either the saw or the dehorning shears are used. As a general thing the corral and chute which form a part of the equipment of every well-appointed cattle ranch are used for this purpose. Dehorning with an ax should never be attempted, as, no matter how keen the edge of the ax or how true the aim of the axman, he is working on a living animal, and only a slight movement of the head would result in a deviation of the stroke, and would thus be liable to cause, if nothing more serious, the infliction of unnecessary pain and suffering to the animal.

It is the usual custom in the West to gather the cattle to be dehorned in a corral, either during the early spring, before the fly season begins, or in the fall, after the fly season has passed. At one side of this corral is a gate opening into another smaller inclosure, which is known as the chute pen. The sides of this converge to form an entrance into a narrow chute, which is usually made long enough for about three cattle, though but one is permitted to enter the working end of the chute at a time, the others being kept back by crossbars. At the front end of this chute is what is known as a squeezer, the formation of which is best understood by a reference to the illustration (fig. 5). After the animal enters the squeezer the squeeze gate is pressed close against its side to prevent lateral movement, the stanchion is closed on the neck, and the head is turned and secured to the post by means of a nose clamp and lead rope, first at one side of the chute and then the other, as required for the removal of the horns.

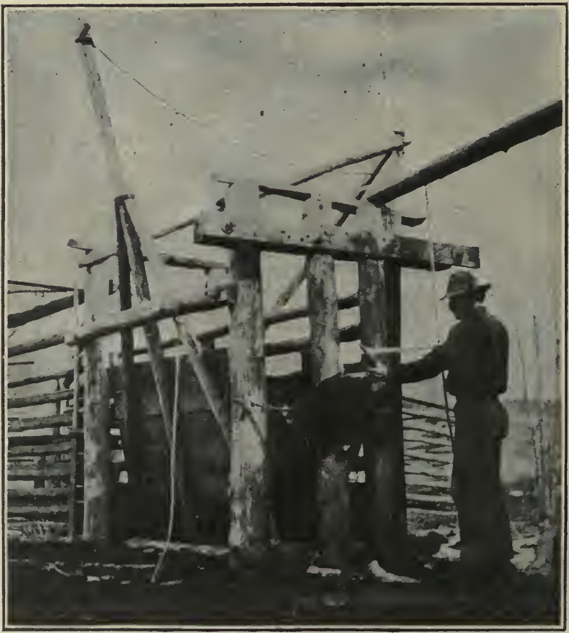

FIG. 5.—Dehorning a steer held in a "squeezer" connected with corral.

In the construction of these chutes it is usual to have on the side opposite the squeeze gate a movable plank which can be taken out to expose the side of the animal for branding. In the entire construction of such a corral and chute it is best not to economize in lumber or bolts, as it should be strong and durable, so that the animal may be controlled without danger to itself or to the operator.

Another method of restraint is to throw the animal and hold it stretched flat on the ground by means of a rope around its neck held by a man on horseback with a turn around the saddle pommel, a second rope being around the hind feet, similarly held by another man on horseback. In the absence of horses these ropes can be secured by taking a turn around a post. After the animal is thus secured an assistant grasps the nose and upper horn, turning the head so that the lower horn can be removed first. This obviates the danger of fracturing the lower horn, and allows the blood to flow directly on the ground and the head to be held flat for the removal of the upper horn. As shown in the illustration (fig. 6) the dehorning shears are frequently used, but there seems to be a tendency in some localities toward giving preference to the saw.

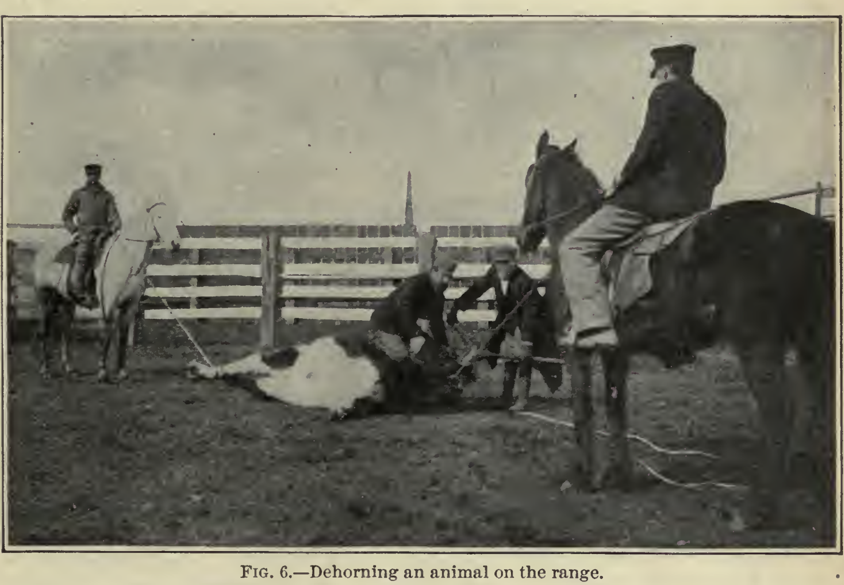

FIG. 6.—Dehorning an animal on the range.

Many ranchmen apply preparations of pine tar and alcohol, or pine tar and turpentine, after dehorning, to lessen the bleeding and keep the flies away.

TO PREVENT HORNS GROWING ON YOUNG CALVES.

When circumstances are favorable, as in the case of farmers who build up their herds by raising the progeny, the horns may be prevented from growing by a simple and practically painless method, and the custom of preventing the growth of the horns is becoming more popular and more generally practiced under all conditions except in the case of calves dropped on the open range. The calf should be treated not later than one week after its birth, preferably when it is from three to five days old. The agent to be used may be either caustic soda or caustic potash, both of which may be procured in the drug stores in the form of sticks about the thickness of an ordinary lead pencil and 5 inches long. These caustics must be handled with care, as they dissolve the cuticle and may make the hands or fingers sore. The preparation of the calf consists in first clipping the hair from the parts, washing clean with soap and warm water, and thoroughly drying with a cloth or towel. The stick of caustic should be wrapped in a piece of paper to protect the hands and fingers, leaving one end of the stick uncovered.

Moisten the uncovered end slightly and rub it on the horn buttons or little points which may be felt on the calf's head, first on one and then the other, alternately, two or three times on each, allowing the caustic to dry after each application. Be very careful to apply the caustic to the horn button only. If it is brought in contact with the surrounding skin it will cause pain. Be very careful also not to have too much moisture on the stick of caustic, as it will remove the skin if allowed to run down over the face. After treatment, keep the calf protected from rain, as water on the head after the application of caustic will cause it to run down over the face. This must be carefully avoided.

Either caustic soda or caustic potash alone, without the admixture of other substances, answers the purpose satisfactorily. Some years ago, however, certain preparations or "dehorning compounds," composed largely of one or the other of these caustics, were generally used, and as inquiries are still occasionally received concerning such preparations, the following formula is given: Combine in an emulsion 50 per cent of caustic soda, 25 per cent of kerosene, and 25 per cent of water. The caustic soda is dissolved in the water and heated to the boiling point, then removed from the fire, and the kerosene added gradually, while the mixture is vigorously stirred. This emulsion is applied in very much the same manner as the stick caustic, except that it is necessary to employ a short, stiff brush. Sometimes a meat skewer is used, the large end being mashed to form a stubby brush. Two or three applications should be made to each horn button, as in the case of the stick caustic, with intervals to allow it to dry.

In the very young calf the horn button, or point that will ultimately develop into a horn, has scarcely any attachment to the skull, and may be felt as a small button embedded in the skin. In this early stage it may be easily removed with a sharp knife or a pair of curved scissors, but even then caustics should be applied to kill any remaining cell life belonging to this germ point; otherwise there may be some subsequent irregular horn growth, which is more or less of a disfigurement.

FARMERS' BULLETINS.

The following is a list, by number, of the Farmers' Bulletins available for distribution. The bulletins entitled "Experiment Station Work" give in brief the results of experiments performed by the State experiment stations. Titles of other bulletins are self-explanatory. Bulletins in this list will be sent free to any address in the United States on application to your Senator, Representative, or Delegate in Congress, or to the Secretary of Agriculture, Washington, D. C. Numbers omitted have been discontinued, being superseded by later bulletins.

22. The Feeding of Farm Animals. PPp. 40.
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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 351.

THE TUBERCULIN TEST OF CATTLE FOR TUBERCULOSIS.

BY

JOHN R. MOHLER, A. M., V. M. D.,

Chief of the Pathological Division, Bureau of Animal Industry.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1909.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY,
Washington, D. C., December 30, 1908.

SIR: I have the honor to transmit herewith a paper on The Tuberculin Test of Cattle for Tuberculosis, by Dr. John R. Mohler, Chief of the Pathological Division of this Bureau.

Tuberculosis of cattle, although not so prevalent in the United States as in some other countries, nevertheless exists here to an alarming extent, especially in some States where no steps have been taken for its suppression. It is estimated that on an average not less than 1 per cent of the beef cattle and 10 per cent of the dairy cattle in the country are affected with this disease, and in some localities the percentages are very much higher. The financial loss from tuberculosis in live stock is not less than $14,000,000 annually.

As the first step in any measure for eradication, either by public authorities or by private owners, it is necessary that there should be some accurate and reliable method of diagnosis. In the great majority of cases it is impossible to detect the disease in the living animal by ordinary physical examination. The tuberculin test, as pointed out by Doctor Mohler, affords the most reliable known method for detecting tuberculosis in cattle, records having proved its accuracy in over 97 per cent of cases, and it has the additional advantage of being harmless.

It is important, however, that a reliable tuberculin be used, as experiments by this Bureau have shown that some of the tuberculin on the market is impotent and worthless. It seems likely that some of the dissatisfaction occasionally experienced with the tuberculin test is due to this fact. The Bureau of Animal Industry prepares a trustworthy tuberculin and furnishes it free of charge to health officers and other public authorities under certain conditions for official use. The Bureau can not, however, supply tuberculin on any terms for private use.

The accompanying paper was included in the Twenty-fourth Annual Report of this Bureau, but in order to make it available for wide distribution in pamphlet form I respectfully recommend its publication also in the Farmers' Bulletin series.

Respectfully,
A. D. MELVIN,
Chief of Bureau.

HON. JAMES WILSON,
Secretary of Agriculture.

THE TUBERCULIN TEST OF CATTLE FOR TUBERCULOSIS.

THE DIAGNOSIS OF TUBERCULOSIS.

The symptoms of tuberculosis in cattle are not sufficiently prominent, except in advanced stages or when superficially located, to enable one to diagnose this disease by the ordinary methods of physical examination. And the cattle may, without showing any clinical symptoms, be in such a stage of tuberculosis as to render them capable of spreading disease. Indeed, an animal may be fat and sleek, eat and milk well, have a bright, glossy coat, and be apparently in the pink of condition, and still be passing tubercle bacilli through the feces or by an occasional cough, and thus endanger all the healthy cattle in the herd. Consequently such adventitious aids to diagnosis as animal inoculation, biological test, serum agglutination reaction, and the tuberculin test are made use of in arriving at a definite opinion relative to the presence or absence of this disease. The value of all but the last of these is discounted by the technique required and by their impracticability, while the tuberculin test is most satisfactory and is the best diagnostic agent known for the disease.

THE ORIGIN OF THE TUBERCULIN TEST.

Tuberculin was invented by Koch in 1890, and was first used experimentally in treating tuberculosis in man. In these cases it was observed that its injection was followed by a rise of temperature, which led veterinarians to apply tuberculin to suspected animals to see if a similar reaction resulted. Numerous experiments showed this to be the case, and since 1891 the use of tuberculin as a diagnostic agent for tuberculosis of cattle has been almost universally adopted in all parts of the civilized world. No one thinks of accepting tuberculin as an absolutely infallible agent, but it is immeasurably more dependable than any other method that has ever been used.

THE NATURE AND APPLICATION OF TUBERCULIN.

Tuberculin is the sterilized and filtered glycerin extract of cultures of tubercle bacilli. It contains the cooked products of the growth of these bacilli, but not the bacilli themselves. Consequently, when this substance is injected under the skin of an animal it is absolutely unable to produce the disease, cause abortion, or otherwise injure the animal. In case the injected animal is normal there is no more effect upon the system than would be expected from the injection of sterile water. However, if the animal is tuberculous, a decided rise of temperature will follow the use of tuberculin.

In practice the tuberculin test is applied by first taking a sufficient number of temperatures, usually three, at intervals of two hours to ascertain the normal variation of temperature of the animal to be tested. The dose of tuberculin (which should always be specified on the label) is then injected hypodermically between 8 and 10 p. m. on the day of taking the preliminary temperatures.[a] On the following day the "after" temperatures are recorded every two hours, beginning at 6 a. m. and continuing until twenty hours following the injection.

THE VALUE AND RELIABILITY OF THE TUBERCULIN TEST.

As a result of this method an accurate diagnosis may be established in over 97 per cent of the cases tested.[b] The relatively few failures in diagnosis are included among two classes of cattle. The first class contains those that are tuberculous but which do not react either because of the slight effect of an ordinary-sized dose of tuberculin on an advanced case of the disease with so much natural tuberculin already in the system, or on account of a previous test with tuberculin which produces a tolerance to this material lasting for about six weeks. The second class includes those that are not tuberculous but which show an elevation of temperature as a result of (*a*) advanced pregnancy; (*b*) the excitement of œstrum; (*c*) concurrent diseases, as inflammation of the lungs, intestines, uterus, udder, or other parts, abortion, retention of afterbirth, indigestion, etc.; (*d*) inclosure in a hot, stuffy stable, especially in summer, or exposure to cold drafts or rains; or (*e*) any change in the method of feeding, watering, or stabling of the animal during the test.

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[a] Great interest has been manifested recently in the cuti tuberculin test of Von Pirquet and the ophthalmo tuberculin test of Wolff-Eisner and Calmette. As their names imply, these tests consist in the application of the tuberculin to the eye and to the scarified skin, respectively, of the animal to be tested. The very favorable results which were reported from the application of both of these methods excited a great deal of interest among investigators, and soon numerous results of the experiments were published, which, however, were not uniformly favorable for either of the tests.

The best results were apparently obtained from the ophthalmo reaction. The changes in the eye resulting from a marked reaction are characteristic; intolerance to light and an increased secretion of tears are the first indications, which may be followed by more severe symptoms, as marked congestion of the conjunctiva, a whitish film-like exudate over the bulbar conjunctiva, and a grayish-yellow discharge from the eye, which, running down the face, forms crusts. The test is applied to only one eye, and in the reaction the other or control eye should remain normal.

Thus far the ophthalmo and cuti tuberculin tests can not be recommended for general practice as methods of diagnosing tuberculosis of bovines, and they will require further work and perfection before they should pass from the experimental stage and be adopted in place of the present reliable subcutaneous application.

[b] Reports of tuberculin tests made in the fifteen years from 1893 to 1908 by Federal, State, and other officers with tuberculin prepared by the Bureau of Animal Industry show that out of 24,784 reacting cattle slaughtered, lesions of tuberculosis were found in 24,387, a percentage of 98.39.

Notwithstanding all these possibilities of error, the results of thousands of tests show that in less than 3 per cent of the cases tested do these failures actually occur. In the first class the chances of error are decidedly reduced by the skilled veterinarian by making careful physical examination and diagnosing these advanced cases, and by the injection of double or triple doses into all recently tested cattle, with the taking of the after temperatures beginning two hours following the injection and continuing hourly for twenty hours. In the second class errors are avoided by eliminating those cases from the test that are nearing parturition or are in heat, or show evidence of the previously mentioned diseases, or exhibit temperatures sufficiently high to make them unreliable for use as normal. Then, in reading after temperatures it is advisable not to recognize as a reaction an elevation of temperature less than 2° F., or one which at the same time does not go above 103.8° F., and the temperature reaction must likewise have the characteristic rainbow curve. (Those cases which approximate but do not reach this standard should be considered as suspicious and held for a retest six weeks later.) In addition, a satisfactory tuberculin must be used, also an accurate thermometer and a reliable syringe in order that a sufficient dose of tuberculin may be given. Finally, the number of apparent errors of the tuberculin test will be greatly diminished if a careful post-mortem examination is made, giving especial attention to the lymph glands.

This low percentage of failures being the case, cattle owners should welcome the tuberculin test not only for their own interest but for the welfare of the public as well. Where this method of diagnosing the disease has been adopted tuberculosis is gradually being eradicated, while it is spreading rapidly and becoming widely disseminated in those districts where the tuberculin test has not been employed. Without its use the disease can not be controlled and the cattle owner is confronted with serious and continuous losses; with its use the disease can be eradicated from the herd, a clean herd established, and the danger of its spread to man removed. Tuberculin may, therefore, be considered a most beneficial discovery for the stock raiser. Strange to say, many of these men have been incredulous, antagonistic, or prejudiced against the tuberculin test by misinterpreting published statements, by incorrect, unsubstantiated, or exaggerated reports, and by alleged injurious effects to healthy cattle.

Law[a] has clearly stated the question when he says:

> Many stock owners still entertain an ignorant and unwarranted dread of the tuberculin test. It is true that when recklessly used by ignorant and careless people it may be made a root of evil, yet as employed by the intelligent and careful expert it is not only perfectly safe, but it is the only known means of ascertaining approximately the actual number affected in a given herd. In most infected herds, living under what are in other respects good hygienic conditions, two-thirds or three-fourths are not to be detected without its aid, so that in clearing a herd from tuberculosis, and placing both herd and products above suspicion, the test becomes essential.
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> In skilled hands the tuberculin test will show at least nine-tenths of all cases of tuberculosis when other methods of diagnosis will not detect one-tenth.

It is perfectly natural that there should be objection to its use among those who are not acquainted with its method of preparation or its properties; but it is difficult to explain the antagonism of farmers who are familiar with the facts connected with the manufacture and use of tuberculin. Probably the most popular objection to tuberculin is that it is too searching, since it discovers cases in which the lesions are small and obscure. While this fact is admitted, it should also be borne in mind that such a small lesion to-day may break down and become widely disseminated in a relatively short period. Therefore any cow affected with tuberculosis, even to a slight degree, must be considered as probably dangerous not only to the other animals in the herd but also to the consumer of her products.

THE HARMLESSNESS OF TUBERCULIN.

Furthermore, tuberculin must be considered as harmless for healthy animals in view of the results revealed by numerous tests covering vast numbers of animals. And it has also been clearly demonstrated that tuberculin interferes in no way with the milking function in healthy cattle; neither in the quantity of milk nor in butterfat value has any variation been detected.

Nocard and Leclainche[b] state:

> Direct experiments and observations collected by thousands show that the tuberculin injections have no unfavorable effect. With healthy animals the system is indifferent to the inoculation; with tuberculous animals it causes only slight changes, which are not at all serious.

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[a] Text Book of Veterinary Medicine, vol. 4, pp. 458, 465. Ithaca, N. Y., 1902.

[b] Les Maladies Microbiennes des Animaux, vol. 2, p. 85. Paris, 1903.

DISPOSAL OF AND INDEMNITY FOR REACTING ANIMALS.

Most of the objections to tuberculin would probably be removed if some method of compensation for the reacting animals could be devised. Thus, in Pennsylvania, where tuberculosis is being eradicated with more success than in any other State, and where there are usually three times as many voluntary requests on file for the application of the test as can be made, all reacting animals are paid for by the State. As the suppression of tuberculosis is a public health measure, it would appear perfectly logical for the State governments to reimburse cattle owners appropriately for the animals condemned and slaughtered. Provision could be made to pay 70 per cent of the appraised value of the condemned animals, not to exceed $30 a head for common stock or $60 for registered stock. Such legislation should also include a requirement for the testing of all dairy and breeding cattle coming into the State.

All tuberculous animals should be slaughtered in abattoirs having competent inspection, and the money obtained from those slight and localized cases which are inspected and passed for food and from the hide and offal of those carcasses condemned as unfit for food should be applied as part payment on the indemnity for their respective owners. The payment of indemnity for tuberculous animals is a good business policy and would do more toward making the tuberculin test popular with cattle owners than any other possible action. And as a corrollary of the latter, more testing would be performed and more tuberculous cattle would be discovered at the start, but the gradual suppression of the disease would soon be manifest, as has been noted in Pennsylvania and Denmark. Furthermore, as Stiles has mentioned, if tuberculosis can be eradicated from dairy herds with but slight loss to the owner, the increase in the price of milk would naturally be inhibited, and the children of poor families would consequently be in less danger of having this very important article of their diet decreased.

CONCLUSIONS REGARDING THE TUBERCULIN TEST.

As a result of the careful study of the tuberculin test, Salmon[a] draws the following conclusions:

1. That the tuberculin test is a wonderfully accurate method of determining whether an animal is affected with tuberculosis.
2. That by the use of tuberculin the animals diseased with tuberculosis may be detected and removed from the herd, thereby eradicating the disease.

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[a] Yearbook of the United States Department of Agriculture, 1901, p. 592.

3. That tuberculin has no injurious effect upon healthy cattle.

4. That the comparatively small number of cattle which have aborted, suffered in health, or fallen off in condition after the tuberculin test were either diseased before the test was made or were affected by some cause other than the tuberculin.

SUMMARY OF DIRECTIONS FOR MAKING THE TUBERCULIN TEST.

1. Stable cattle under usual conditions and among usual surroundings, feeding and watering in the customary manner.

2. Make a physical examination of each animal, and give to each one some designation by which the animal will be known throughout the test.

3. Take each animal's temperature at least three times at two or three hour intervals on the day of injection; for instance, at 2, 5, and 8 p. m.

4. At 8 or 10 p. m. inject a dose of tuberculin under the skin in the region of the shoulder, using a sterile hypodermic syringe after disinfecting the skin at the seat of injection with a 5 per cent solution of carbolic acid or a similar antiseptic solution.

5. Tuberculin is not always concentrated to the same degree, and therefore the dose, which should always appear on the label, varies considerably. The dose of imported tuberculin is 0.25 c. c. for an adult cow, and before injection is diluted with sterile water to 2 c. c. The tuberculin made by the Bureau of Animal Industry is prepared so that it will not be necessary to dilute it, and the dose is 2 c. c. for an adult animal. Yearlings and 2-year-olds, according to size, should receive from 1 to 1½ c. c., while bulls and very large animals may receive 3 c. c.

6. At 6 a. m. on the day following the injection of tuberculin commence taking temperatures, and continue every two or three hours until the twentieth hour after injection, at which time if there is no tendency for the temperature to rise the test may cease.

7. A rise of 2° F. or more above the maximum temperature observed on the previous day, providing the temperature after injection exceeds 103.8° F., should be regarded as an indication of tuberculosis. Those cases which approximate but do not reach this standard should be considered as suspicious and held for a retest six weeks later, giving double the original dose.

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Issued March 20, 1909.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 352.

THE NEVADA MOUSE PLAGUE OF 1907-8.

BY

STANLEY E. PIPER,
Assistant, Biological Survey.

1862 1889

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1909.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Biological Survey,
Washington, D. C., January 12, 1909.

Sir: I have the honor to transmit herewith, and to recommend for publication as a Farmers' Bulletin, a report on the Nevada Mouse Plague of 1907–8, by S. E. Piper, an assistant in the Biological Survey.

The report is important from three points of view: (1) It is the first account we have ever had of a fully developed mouse plague in America; (2) it shows that such plagues may be successfully combated; and (3) it emphasizes the necessity for protecting our native hawks and owls and the smaller predatory mammals in order to prevent the recurrence of such plagues in future.

Respectfully,

C. Hart Merriam,
Chief, Biological Survey.

Hon. James Wilson,
Secretary of Agriculture.

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THE NEVADA MOUSE PLAGUE OF 1907-8.

INTRODUCTION.

This bulletin gives an account of the recent mouse plague in Humboldt Valley, Nevada. Its object is to acquaint farmers with the dangers from field mice and to describe the best methods of destroying and controlling the animals. Though referring particularly to the Nevada outbreak, the recommendations apply to similar species in other parts of the United States.

THE MOUSE PLAGUE IN HUMBOLDT VALLEY.

HISTORY OF THE OUTBREAK.

Damage by field mice attracted the attention of the ranchmen in the lower part of Humboldt Valley early in the spring of 1906 and became severe during the following summer.[a] In the fall and winter of 1906–7, damage had increased until fields here and there in the valley were seriously injured. Extensive ravages first occurred above and about Lovelocks. In May, 1907, fields on the Rodgers ranch, 5 miles below Lovelocks, were invaded from the lands farther up the valley, the progress of the mice being plainly marked, as the fields above the Rodgers ranch suffered first. The movement of this great body of mice, it should be noted, was a gradual, scattering progression, first by a few and later by increasing numbers, until the greater part had moved to fresh fields. Numbers, however, finding conditions improved, remained as stragglers in the fields deserted by the main body.

By October, 1907, a large part of the cultivated lands in this district had been overrun by vast numbers of mice. The yield of hay had been reduced by one-third; potatoes and root crops were largely destroyed; many alfalfa fields were ruined by the mice eating the roots of the plants; and the complete destruction of this, the chief crop in the valley, was threatened.

The height of abundance was reached in November, when it was estimated that on many large ranches there were from 8,000 to 12,000 mice to each acre.[a] The fields were riddled by their holes, which were scarcely a step apart, and over large areas averaged 150 to 175 to the square rod. Ditch embankments were honeycombed, and the scene was one of devastation. Serious losses in hay and root crops during the summer proved but a slight forerunner of the damage which began in the fall with the disappearance of green food. Burrowing down about the plants, and extending their underground runs from root to root, they either killed or seriously injured the alfalfa (fig. 1). By November they had destroyed so large a percentage of the plants that many fields were plowed up as hopelessly ruined (see fig. 2). They attacked also the roots of trees, seriously injuring or quite destroying orchards. They killed most of the young shade trees planted along ditches, and so completely girdled large Lombardy and silver poplars (fig. 3) that in some cases they caused the death of even such hardy trees.

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[a] Reported by J. S. Cotton, Sept., 1906.

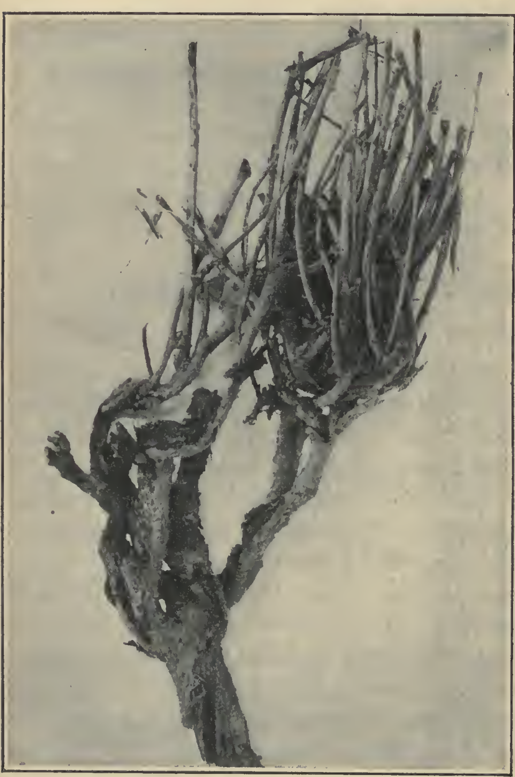

FIG. 1.—Alfalfa plant killed by field mice.

By January, 1908, in fields where the mice had existed by thousands the previous summer and fall, comparatively few, possibly 200 to 500 to each acre, remained. The border of the destroyed district was about 6 miles below Lovelocks, and the mice were gradually moving further down the valley. In the area below this, mice were somewhat in excess of normal numbers and in several centers of abundance had seriously injured fields. Even where most abundant, along the lower border of the affected area, they did not exceed 1,500 to the acre. In the winter they attacked every available food supply. Small willows and even greasewood bushes about the borders of fields were stripped of all the bark within reach, and horse and cattle droppings were gnawed to pieces for the food they contained. Alfalfa roots, however, were the food supply on which the mice were chiefly dependent.

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[a] Reported by Vernon Bailey, Nov., 1907.

EFFORTS OF RANCHMEN TO COMBAT THE PLAGUE.

In Nevada, the great majority of ranchmen knew neither what to expect from such great numbers of mice nor how to check them. It must be said, however, that no previous examples of successfully controlling such plagues exist; usually they have run their courses until brought to an end by natural agencies. Hence it is not surprising that in Humboldt Valley no concerted or systematic efforts to suppress the plague in its earlier stages were undertaken, but after the mice swarmed in thousands over the fields many attempts were made to destroy them by distributing wheat poisoned with phosphorus. These, however, were spasmodic and generally proved futile, as the fields experimented on were quickly reinvaded from adjoining lands. While a few fields favorably located were saved by early poisoning, the results of such unsystematic efforts amounted to practically nothing in overcoming or even materially checking the plague.

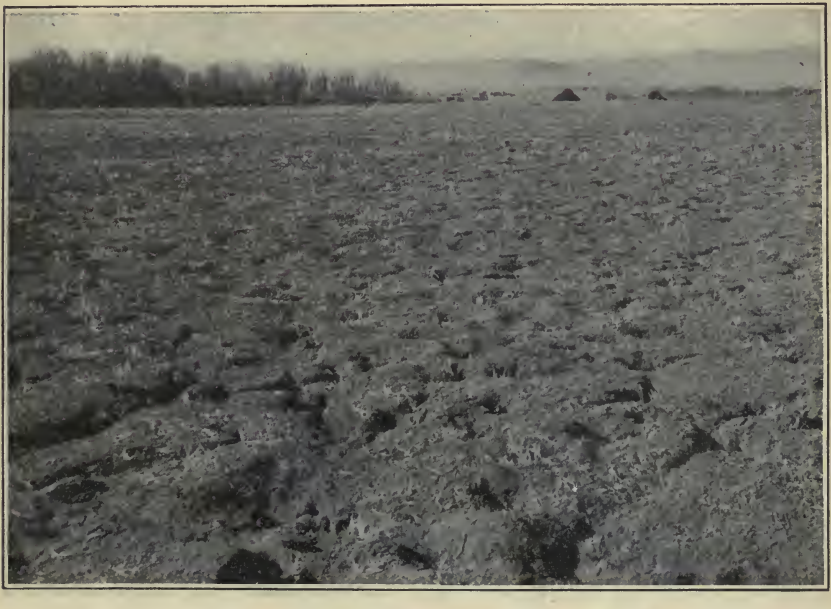

FIG. 2.—Alfalfa field ruined by mice, showing general condition of fields in Humboldt Valley in January, 1907.

The preparation in general use by ranchmen consisted of wheat treated with a strong solution of yellow phosphorus in carbon bisulphid, a cheap and effective poison for field mice, but inflammable, explosive, and dangerous to birds. As a result of its extensive employment in the valley, California quail, an introduced species, were decimated, and magpies, crows, meadow larks, and smaller seed-eating birds suffered extremely. On one occasion 67 horned larks were found dead on about 4 acres a few hours after the poisoned grain had been distributed. Fortunately hawks, owls, gulls, and ravens were not affected, but many skunks and domestic cats were killed as the result of eating mice dying or dead of phosphorus. Several accidents occurred in handling the solution, and cases of fatal poisoning of live stock were frequent.

Several attempts by ranchmen to induce contagious diseases among the mice by means of advertised bacterial preparations failed.

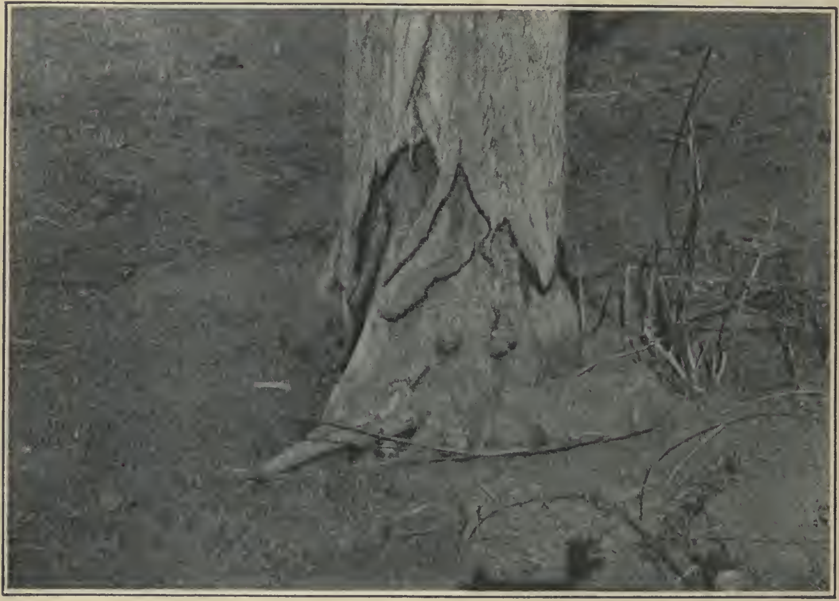

FIG. 3.—Lombardy poplar girdled and killed by field mice.

HOW THE OUTBREAK WAS FINALLY CONTROLLED.

Chiefly through the cooperation of Mr. George S. Webb, manager of the large Rodgers ranch, systematic experiments to destroy the pests, undertaken early in January by the Biological Survey, yielded results demonstrating that such mouse plagues can be controlled, and the greater part of the losses prevented. The experiments proved that mice could be effectively destroyed in winter by alfalfa hay poisoned with strychnia sulphate, and this preparation was generally recommended in the valley. On the Rodgers and Anker ranches a force of 7 to 15 men was employed to distribute the poison in the fields, with most satisfactory results, and without the dangers incident to the use of phosphorus and grain.

During this winter season, when the mice were not breeding, large numbers of predatory birds and mammals had steadily depleted their numbers. Mortality, believed to be due to disease, perhaps engendered by the straitened food supply and the severe winter weather, had been everywhere evident. Dead and dying mice attracted general notice, and in opening burrows where no poison had been distributed dead mice were frequently found in their nests.

By March 15, poisoning, supplemented by these natural agencies, had destroyed the mice on several thousands of acres where they were most abundant, and the plague was broken before the remaining alfalfa fields had been overrun. In scattered centers mice continued in destructive numbers until May, but without regaining to any considerable extent by reproduction, they steadily decreased. Later in the summer they had almost disappeared from the valley.

ESTIMATES OF DAMAGE.

The scourge of mice swept over about four-fifths of the cultivated area in the lower part of Humboldt Valley. Of about 20,000 acres in alfalfa, about 15,000 were so seriously injured as to require plowing and replanting. Over most of this area the alfalfa was replaced by grain crops for the season of 1908, at great expense and loss, since good alfalfa lands pay gross returns of from $60 to $70 per acre, while good grain crops return only $35 or $40 per acre.

The shortage of hay on the Rodgers ranch, where 2,200 acres were in alfalfa, was estimated at 2,000 tons. On Anker's ranch of 650 acres, it was estimated at 600 tons. Other ranches suffered in proportion, and the loss of hay in the valley amounted to not less than $50,000. The following estimates, independently considered, indicate the severity of the depredations. W. C. Pitt, who farms 1,400 acres of alfalfa, estimates his complete loss at $20 per acre, or $28,000. John Font estimates his damage on 1,000 acres at $20,000, and Mr. Anker considers his loss on 650 acres to be $8,000. Mr. Webb, on the Rodgers ranch, figures the complete loss on 2,200 acres, part of which pays considerably short of the best returns, at $30,500.

A careful consideration of the losses in hay, pasturage, root crops, and trees, the expense of restoring alfalfa fields to their former condition, and deducting the value of a grain crop for 1908 shows the average loss to be about $20 per acre.[a] On this basis the damage to the valley amounts to $300,000. Allowing for the saving of a few fields by early poisoning, and for others not entirely destroyed, the loss may have been a little less than $300,000.

Simultaneously with the plague in the lower part of Humboldt Valley mice appeared in enormous numbers farther up the Humboldt

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[a] Figured on the basis of 1,000 acres on Rodgers ranch.

River and its tributaries about Winnemucca, Battle Mountain, and in Paradise and Little Humboldt valleys. As the lands infested in those districts were chiefly great natural hay meadows of red top and wild clover, the damage was less severe. However, gardens and isolated alfalfa fields were seriously injured. Later, reports of mice in alarming abundance were received from King River, Quinn River, and Carson and Smith valleys, Nevada; from Weber River Valley, and from Sanpete and Utah counties, Utah; and from Honey Lake Valley, California. In none of these localities was the damage so extensive as in Humboldt Valley, though plagues of like severity were plainly threatened.

A PLAGUE THREATENED IN CARSON VALLEY.

Reports of severe damage by mice in Carson Valley, a hundred miles southwest of Lovelocks, in April, 1908, led to investigations which have an important bearing on the subject. Carson and Humboldt valleys are alike in having large areas in alfalfa bordered by desert lands on which field mice do not live. On a tract of about 2,500 acres near Minden, mice were found to be excessively abundant, and in some fields 10 to 25 per cent of the alfalfa plants had already been destroyed. Several smaller centers were similarly affected, while over the valley generally the mice were somewhat in excess of normal numbers. This was a condition similar to that presented in Humboldt Valley during the spring of 1907, and young of all sizes were abundant. Examination of many females, a large percentage of which were pregnant, showed an average of from 6 to 7 young, while in a number as many as 10 were found. Many females suckling young were found to be again pregnant. This was in marked contrast with the condition in Humboldt Valley, where, at this time, the mice were steadily decreasing without any general reproduction. The mortality among the mice so strongly in evidence during the winter and spring in Humboldt Valley was not found here. In fact, the pests were plainly increasing; while in Humboldt Valley they were steadily diminishing. Reproduction at the rate noted at Minden might and probably would have resulted in a plague by fall.

It can not be too strongly emphasized that at this stage of development mouse plagues can be checked, as was demonstrated by results actually obtained here. Although alfalfa was already well grown, furnishing the mice abundant food, by systematic poisoning they were so effectively reduced in the infested areas as not to be dangerous again during the season—in other words, a plague was averted.

PREVIOUS OUTBREAKS.

This is not the first time that field mice have inflicted serious damage in Humboldt Valley. Accounts by the older ranchmen indicate that a similar scourge occurred from 1889 to 1892. The mice were very abundant during the period from 1899 to 1901, the outbreak approaching in severity the present one, though affecting less of the valley. Between these periods damage of more local nature was frequent. The same species was reported to be extremely abundant and very injurious to crops in Carson Valley in 1892,[a] and several times since it has seriously menaced the valley.

ORIGIN AND PROGRESS OF SUCH PLAGUES.

A few observations on the development of this mouse plague are pertinent, since they bear directly upon the control or prevention of similar irruptions in the future. Always present in Humboldt Valley, these mice attract little attention when in small numbers. Usually they are not uniformly abundant in the district; in fact in many of the fields they may not be present at all. They live in scattered colonies in swampy places; along the borders of sloughs and irrigation ditches; in salt grass patches and in similar damp areas. When in normal numbers a little damage may be noticeable about the borders of fields or along ditches, where plants have been killed during winter and spring. Ordinarily the mice are very prolific, each pair producing 4 to 6 litters of about 6 young each during the long breeding season, which extends from March to November; and probably the young born early in the season breed before fall. Occasionally conditions favor excessive multiplication, and under such circumstances damage soon becomes evident, and in a single season may increase locally to the serious injury of fields. Extending from such centers during the next breeding season, and increasing not only by reproduction but by joining with other colonies, a vast army of mice is formed. Because of overcrowding and the limitation of food, such armies invade adjoining districts, and this progress becomes more rapid with the disappearance of green food in the fall. Through the combination of several such armies, entire districts are overrun.

Mice plagues usually develop within the affected districts. The essential point is this: It takes several seasons to produce a general plague of mice, and damage is noticeable for at least a season before a serious outbreak occurs. Though natural agencies may be depended upon to overcome such abnormal numbers finally; yet, unless active repressive measures are taken, enormous damage to crops will result. Control, easy at first, becomes more and more difficult as the mice increase in numbers, and, after a plague is well established, is very expensive.

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[a] W. W. Price, Zoe. Vol. 4, 1893–4.

THE SPECIES RESPONSIBLE FOR THE PLAGUE.

The mouse which produced the plague in Nevada, locally known as "black mouse" (fig. 4), proved to be the Carson field mouse (*Microtus montanus*), one of the numerous species of short-tailed field mice or meadow mice, a group which has caused widespread destruction in various parts of the world.[a] This field mouse is rather widely distributed in the valleys of Utah, Nevada, northeastern California, and eastern Oregon. In nearly all parts of the United States short-tailed field mice are among the most abundant of mammals, and a number of species in widely separated localities have occasionally exhibited the same tendency to excessive increase, indicating that favoring conditions may produce mouse plagues wherever the mice exist. Even when in small numbers they destroy considerable clover and alfalfa and injure orchards, nurseries, and root crops.

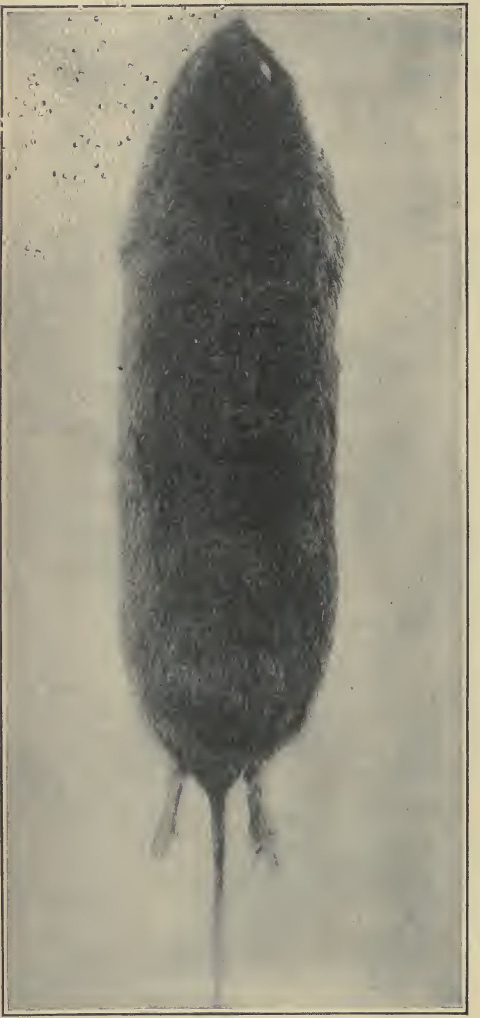

Fig. 4.—The Carson field mouse (*Microtus montanus*).

This is the first recorded instance of an irruption of field mice in North America attaining the proportions of a plague. The experience indicates the probability of future and even more disastrous outbreaks. In the extensive reclaimed areas of the West the abundant food and luxurious cover furnished by alfalfa fields and the miles of irrigation ditches, which afford these mice suitable homes along their banks, greatly favor their increase, while surrounding desert conditions limit the spread of mice beyond the cultivated areas.

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[a] For an account of the group see Bulletin 31, Biological Survey.

REPRESSIVE MEASURES.

POISONS.

Without doubt poisoning is the best method at present known of dealing with field mice on an extensive scale. Besides effectiveness, poisons should possess the additional advantage of small cost and the least possible danger to man, to domestic stock, and to valuable wild birds and animals. Comparative tests of a large number of poisons, including strychnine, phosphorus, lead acetate, mercuric chloride, arsenic and its compounds, proved strychnia sulphate by far the best and most practicable. Used in proper proportions it is no more costly than arsenic, lead acetate, or mercuric chloride. Moreover, it is much more readily eaten than are these poisons, which render some of the best baits unattractive to mice. Used on wheat it is considerably more expensive than phosphorus, but possesses many advantages; however, it may be used on mediums which make it the cheapest poison practicable.

Phosphorus.—Yellow phosphorus is exceedingly dangerous to handle and sometimes causes disastrous fires. Its solution in carbon bisulphid is highly explosive, while wheat grains poisoned with it are eaten readily by many birds. Thus the wheat poisoned with this solution, used by many Nevada ranchmen, was as dangerous a poison to prepare and to use as could well be devised. The preparation was in the form of a rapidly diffusing liquid, of which six ounces were sufficient to poison a sack of wheat.

Many ranchmen adopted the method of broadcasting the poisoned wheat over their fields, either by means of broadcast seeders or by hand. About 40 pounds of grain were required for each acre. Though many mice were killed, this method falls far short of yielding the best results. It is not much cheaper than other methods, as the proportion of poisoned grain wasted makes up for the lessened labor. Furthermore, its use is attended with the greatest possible danger to birds.

A much better method of distributing this poisoned grain is to drop about half a teaspoonful into each mouse burrow. Field mice limit their movements to their own systems of trails and burrows, and it is essential to place a fatal dose of poison within reach of each mouse. About 90 per cent of the mice were killed by this method, but in the worst-infested fields a man could cover only three or four acres a day, and the average cost, including labor, was from 80 to 90 cents per acre.

Strychnine.—Strychnine is commonly on the market in two forms. For the purpose of poisoning field mice, care should be taken to procure strychnia sulphate, as this is much more readily soluble in water than ordinary strychnine crystals. Even in powdered form, the sulphate is required. It fluctuates considerably in price, but usually can be obtained wholesale at about 75 cents an ounce.

Poisons should always be prepared at a distance from the house, where stock and poultry are not endangered. To avoid danger to persons strychnine and the vessels in which it is used should, of course, be carefully handled and safely stored away when not in use. Ordinary 5-gallon oil cans, for which covers and wire handles have been provided, make excellent utensils. A firehole about 2 feet long and a foot wide, over which two iron rods are placed to support the cans, makes a fireplace where the solutions can be quickly prepared. Galvanized iron wash tubs are suitable for mixing the material if grain be used. For preparing poisoned alfalfa on the large scale usually necessary, a large metal receptacle which will permit the mixing of 30 pounds of hay at once is required. One or two oil cans marked into gallon measures, a sprinkling can, and several large strong spoons complete a handy outfit for preparing poisons.

BAITS FOR THE ADMINISTRATION OF POISON.

Tests with various baits or vehicles for poison show that three possess distinct advantages. These are alfalfa hay, green alfalfa, and crushed wheat.

Alfalfa hay.—Alfalfa hay was found to be the best vehicle or medium for carrying the poison in winter. It was used extensively in Humboldt Valley up to the time green food appeared in March. A single treatment of the fields destroyed from 85 to 95 per cent of the mice. Compared to the grain-phosphorus preparation it steadily gave as good or better results, and is about 30 per cent cheaper; furthermore, it is entirely without danger to birds.

Formula.

Chopped alfalfa hay	30 pounds.
Strychnia sulphate	1 ounce.
Water	5 or 6 gallons.[a]

The alfalfa hay should be fresh and green rather than bleached. Either chopped hay, including stems and leaves, or the fine material, chiefly leaves and blossoms from the bases of stacks, may be used. The chopped hay is preferable, since the stems retain the moisture longer. The hay should be chopped into about 2-inch lengths, an ordinary feed cutter being best for the purpose. The required quantity should be placed in a large metal receptacle, sprinkled with 3 gallons of fresh water, and well mixed with a pitchfork. Dissolve 1 ounce of strychnia sulphate in 2 or 3 gallons of water by heating in a closed vessel. Sprinkle the solution over the dampened hay and mix well until the moisture is all taken up. The hay may now be sacked and is ready for use.

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[a] Or as much as the hay will absorb.

Only enough of the material for immediate distribution should be prepared, as it deteriorates when kept for several days. It is best distributed by hand (fig. 5), placing a small pinch, equal to a teaspoonful, near the entrance of each burrow, and scattering a little here and there along the surface trails. Care should be taken to place the poison a little to one side of the mound (fig. 6) to prevent it from being covered by the earth thrown out. In cold weather, when the mice move about chiefly in their underground runs, it should be dropped *into the burrows*. The dampening of the hay freshens it remarkably and makes it a tempting substitute for green food. Many of the animals eating it die on the surface, but about 60 per cent of those destroyed die underground. The poison is effective for several days, and since much of it is carried into the burrows to be eaten later, its full effect is not at once evident.

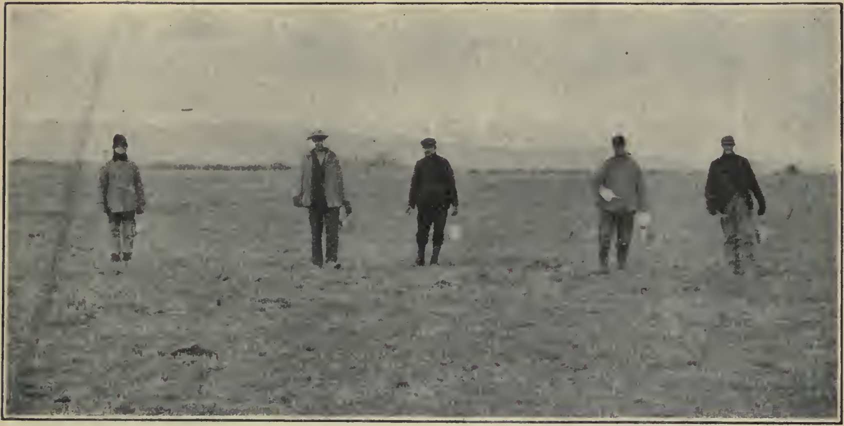

FIG. 5.—Men distributing poison.

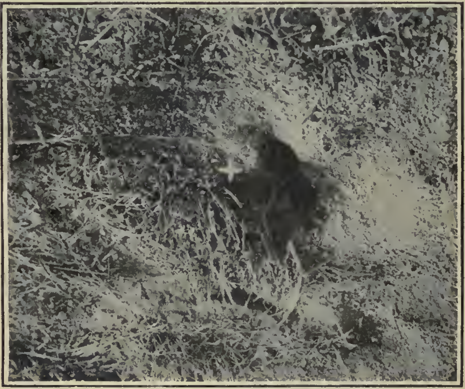

FIG. 6.—Where to place the poison.

Some farmers hesitate to distribute poisoned hay over their land for fear of poisoning stock. If properly done, however, there is practically no danger. The proportion of strychnine is small and calculated especially for mice. Rain or the irrigation of fields renders harmless any of the material left, and the small quantity it is necessary to put out soon shrivels to almost nothing from exposure to the sun. In Humboldt Valley extensive poisoning was not attended by a single accident. It is recommended, however, that stock be kept out of fields for a few days after poison has been distributed.

Green alfalfa.—In Carson Valley, in April, poisoning with green alfalfa hay was strikingly successful. Although the experiments in alfalfa fields were in places where green food was abundant, still nearly all the mice were killed in the areas treated (fig. 7). These animals habitually cut and store sections of alfalfa shoots during summer, and it is not surprising that the same material poisoned and placed in their runs should prove effective.

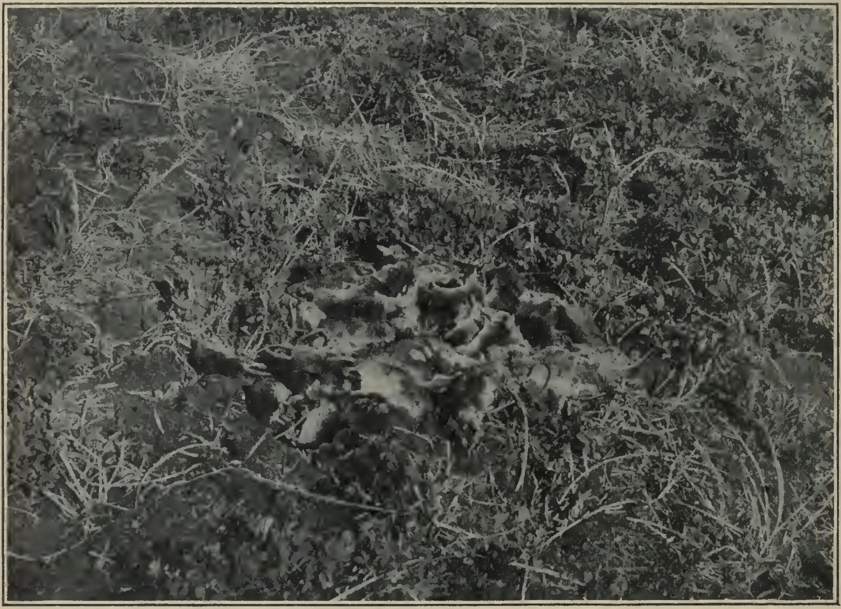

FIG. 7.—Field mice poisoned by green alfalfa.

Formula.

Green alfalfa	45 pounds.
Strychnia sulphate	1 ounce.
Water	1½ gallons.

Procure fresh green alfalfa, preferably young shoots, though leaves and tops of older plants also are good. Chop into lengths of 2 or 3 inches and place in a water-tight receptacle. Heat the strychnia in half a gallon of water in a closed vessel until thoroughly dissolved. Add the poisoned solution to one gallon of cold water and sprinkle it slowly over the alfalfa, mixing until the moisture is all taken up. In general the same method of distribution recommended for alfalfa hay should be followed. Several short pieces are sufficient for each burrow. Owing to the abundance of green food, greater care should be exercised in placing baits in the holes and along runways. As green alfalfa withers quickly when exposed to the sun, evening hours or cloudy days are best for its distribution. Though it can hardly be used extensively enough to suppress well-established plagues, it is recommended for small areas, or where mice are not excessively numerous. It is especially valuable for destroying mice along ditch banks or about the borders of fields during the irrigation of fields in summer.

Crushed wheat.—Crushed wheat possesses decided advantages over whole grain as a medium for poison. It is easier to prepare, and is more readily eaten, especially by young mice in summer. While considerably more costly than the phosphorus preparation, it is much less objectionable. The cost is not serious when mice are not extremely abundant over large areas, or when it is used to prevent plagues in the earlier stages.

Formula.

Crushed wheat	60 pounds.
Strychnia sulphate	1 ounce.
Water	2 gallons.

Heat the strychnia sulphate in the water in a closed vessel until completely dissolved. Sprinkle the solution over the wheat and mix well. Sweetening or scenting the preparation is unnecessary and even detrimental. When it is desirable to keep the poison several days, add two tablespoonfuls of powdered borax to prevent fermentation.

This preparation was used extensively in Carson Valley in April to check a plague of mice before alfalfa became too high to prevent effective poisoning. About 85 per cent of the mice were killed by a single treatment, and this was followed later by poisoning along the ditches and in other places where the animals persisted. The cost was about 40 cents per acre.

During these operations many blackbirds and magpies were poisoned. To a less extent meadow larks, killdeer, and mourning doves were destroyed. Though in this instance poisoned grain could not be replaced by less destructive preparations, it should, when possible, give place to poisoned green alfalfa. Winter poisoning with alfalfa hay will usually prevent the necessity for summer poisoning.

OBLITERATING BURROWS.

In the lands traversed by the scourge in Humboldt Valley, where over large areas mouse holes were scarcely a step apart, it was at once evident that there was great waste of material and labor in poisoning. Usually there were ten or more holes for each pair of mice, and in fields partially deserted the proportion of unoccupied holes was much greater. When all the holes were obliterated, the mice soon reopened those occupied, and poisoning could be done with the certainty of treating only the occupied burrows. A brush drag (fig. 8) proved best for the purpose. By this method a saving of about 40 per cent in labor and material resulted, and the average cost of destroying mice with alfalfa hay was reduced to about 35 cents per acre. While obliterating holes is practicable only under such extreme conditions as were presented in Humboldt Valley (fig. 9), it there proved of the greatest importance.

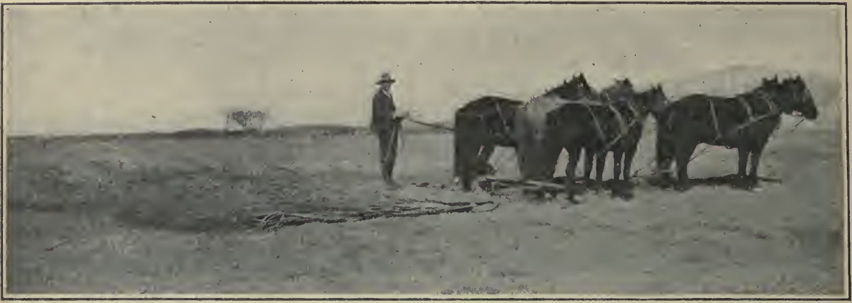

Fig. 8.—Brush drag used to obliterate mouse holes.

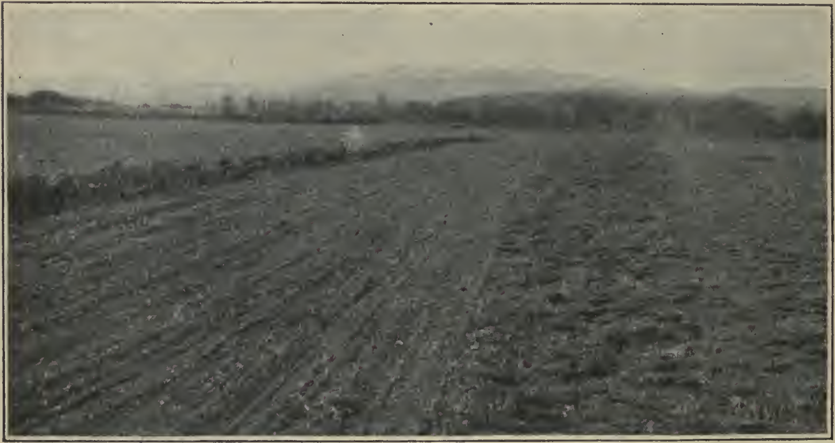

Fig. 9.—Effect of brush drag, showing mouse holes in part not dragged.

IRRIGATION.

Though irrigating in summer destroys a large percentage of the very young mice, it does not considerably reduce the number of adults. Moving ahead of the flood, they dart in and out of holes already full of water, swimming considerable distances through their underground tunnels. They cross ditches and furrows readily, traveling by water almost as easily as by land. Many take refuge in elevated spots and in straw or other litter in the fields, but by far the greater number are driven to the elevated ditch embankments and to the borders of fields. Within a few days after the water is withdrawn they again abound in the fields. Irrigation affords many opportunities for destroying the mice, both by poisoning and by dogs. It has also the effect of obliterating the burrows, so that for the next few days poisoning can be practiced with greater saving, since the occupied burrows are easily recognizable.

WINTER FLOODING.

It is said that flooding the fields in cold winter weather is an effective method of destroying mice, as when forced out of their burrows they soon perish from exposure, or are easily killed by dogs. This method has been successfully practiced in Carson Valley, and appears to be well worth trial. It can not be practiced in all irrigated districts, however, on account of the shortage of water at this season. It should be accompanied by poisoning along the ditch embankments and about the borders of fields.

BURNING.

In and about cultivated fields are many little areas where mice breed undisturbed. Waste strips along streams, swampy areas, and, on a larger scale, natural hay lands, serve as breeding places from which cultivated fields are invaded. Poisoning is not usually practicable in such places. Burning off the rank grass and weeds in winter or early spring is a great help in controlling field mice. Many of them perish, and the land is made uninhabitable for the survivors, driving them to locations where they may be more readily destroyed. In concerted attempts to control field mice, burning such areas should always precede poisoning operations.

DESTRUCTION OF WINTER COVER.

Very important in any attempt to control field mice is the keeping down of rank grass and other cover along ditches and about the borders of fields. The grass in such places is frequently left in haying time, because of the difficulty in cutting it. The last growth of alfalfa is often left to be killed by frost, when it should be pastured off or otherwise disposed of. Such cover affords the mice excellent protection from hawks, owls, and other predaceous birds.

PROTECTION OF TREES.

Clean cultivation is the greatest safeguard to trees. Where rank grass, weeds, or cover crops are allowed to remain under the trees in winter, the attack of field mice is invited. Damage to orchards is usually done under cover of weeds and snow and may reach serious proportions before being noticed. Many trees may be so badly injured that recovery is impossible, but most of them can usually be saved by promptly banking up earth about the trunks, entirely covering the wounded parts.

For protecting young trees thin wooden wrappers, called "tree protectors," are valuable. It is also highly probable that the lime and sulphur wash used by entomologists would prove effective. It should be applied at the beginning of winter.

DOGS AS MOUSE DESTROYERS.

Dogs are worth many times their keep when trained to hunt mice. Fox terriers or other small breeds take readily to hunting them and during irrigation and plowing destroy great numbers. Many farmers in Nevada keep dogs for the purpose of killing ground squirrels, pocket gophers, and field mice as they are forced out of their burrows by water, and in this way keep the pests in check. Plows turn out of the burrows practically all the field mice present, so that they become easy victims for dogs. Dogs trained to follow plows very materially reduce the number of mice in the areas covered. As an inexpensive and effective help in controlling field mice, dogs can not be too highly recommended.

SUMMARY OF REPRESSIVE MEASURES.

It has been proved that field mice are easily controlled by poisoning, or by a combination of poisoning and other methods, so there is little excuse for permitting mouse plagues to develop. Constant attention is obviously the way to avert such scourges. The encouragement of natural enemies, the destruction of rank cover, the keeping of well-trained dogs, and a little poisoning in winter, are ordinarily sufficient to hold the pests in check.

On account of its extremely dangerous character and the widespread destruction it causes, the use of phosphorus is not advised, especially since strychnia sulphate is fully as destructive to the mice at no greater cost. When mice are abundant in winter and early spring, thorough treatment with poisoned alfalfa hay will usually prevent serious damage in summer. When from neglect of this, or through other cause, it is necessary to destroy mice in summer, poisoned green alfalfa will commonly suffice. To avert threatened plagues at this season, where it is necessary to treat large areas quickly, poisoned crushed wheat is the best agent to employ.

NATURAL ENEMIES OF FIELD MICE.

Of the many remarkable features of the mouse plague in Humboldt Valley, none is of greater interest, or indeed, of greater significance, than the large numbers of birds and mammals which gathered to feed on the mice. In all other localities menaced these valuable allies of the farmer appeared in similar abundance. Under rows of trees, about the bases of fence posts, and scattered everywhere in the fields were regurgitated pellets of mouse fur and bones, affording abundant proof of the services rendered by birds; while many holes and destroyed nests in the fields showed the work done by skunks and coyotes. So apparent was the assistance rendered by these creatures that it attracted the attention and secured the protection of the farmers, many even sparing the coyote, whose services as a mouse destroyer deserve to be more widely recognized. In Nevada coyotes were frequently seen catching mice in the daytime, and their droppings were composed entirely of mouse fur and bones.

It is deplorable that, even when their usefulness is as apparent as here, some persons continue to destroy valuable birds and mammals. During the investigations in Humboldt Valley, no less than 29 large hawks were found hanging on wire fences, their useful lives ended by thoughtless gunners.

The striking evidence of the valuable services of the natural enemies of mice seen during this plague is but an example of their constant value. Hawks, owls, gulls, crows, ravens, herons, and shrikes among birds; and skunks, coyotes, foxes, weasels, badgers, and wildcats among mammals habitually prey upon field mice, and are most valuable in preventing undue increase of these pests.

Thorough studies have shown hawks and owls to be most beneficial allies of the farmer, orchardist, and nurseryman.[a] Most species rarely, and many of them never, attack poultry. But even were the depredations of the several species which kill poultry much more considerable, a small price would be paid for their services in destroying rodents. In the Nevada valleys all species of hawks and owls are distinctly beneficial, and here rigorous protection can not be too strongly advocated.

Among mammals the weasel and the skunk are especially worthy of protection. They are most persistent enemies of mice, and are less likely to be driven out by civilization than are other mammals. When particular individuals raid poultry houses it may be necessary to destroy them, though usually it is easy to make such houses proof against their attacks. Far from being a menace, they are generally most beneficial mammals, and living, are worth many times the value of their pelts.

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[a] See Circular No. 61 of the Biological Survey, Hawks and Owls from the Standpoint of the Farmer.

It is gratifying to note that in many localities the people are learning to appreciate these natural enemies of rodent pests, for even more important than legislation for the protection of valuable birds and animals is the recognition of their services by the farmers.

In Nevada it was noticed that hawks and owls hunted chiefly in fields near the few plantations of large trees to be found in the valleys. Beneath these trees the ground was fairly carpeted by disgorged pellets of fur and bones, representing thousands of mice. While certain species of hawks seldom frequent trees, others habitually perch in them, notably the large rough-leg, Swainson, and red-tail, which were the most abundant and persistent mousers. In nearly all of the valleys, even those which have been farmed for years, the absence of trees is notable. More trees along ditches, about the borders of fields, and in groves here and there would doubtless increase the number of valuable resident hawks and owls and attract more winter visitors.

CONCLUSIONS.

The plague of field mice in Nevada illustrates the dangerous proclivities of this group of rodents and stamps them as most serious pests. Since field mice possess in marked degree the tendency to periodic excessive multiplication, plagues are possible wherever they exist. In view of the natural increase of field mice resulting from the reclamation of desert lands and the gradual extirpation of their natural enemies, mouse plagues of vastly greater proportions are by no means improbable.

An understanding of the manner in which such plagues develop is essential in attempts to prevent them. Control, easy in the beginning, becomes very difficult and expensive after a plague is well established. In Humboldt Valley, in the beginning, a little poisoning with green alfalfa or crushed wheat would have sufficed to prevent the plague. During the fall and winter of 1906–7, when the mice seriously injured fields here and there, they could have been destroyed with poisoned alfalfa hay. Even during the summer of 1907 concerted and vigorous poisoning would have destroyed them at a cost small indeed in comparison with the damage they inflicted later.

Winter poisoning with alfalfa hay is the most practicable, since the absence of green herbage is a distinct advantage. Ordinarily, poisoning in winter will prevent the necessity for it in summer. When, however, mice appear in alarming numbers in spring they should be promptly suppressed, since under these conditions a plague may be well established by fall. But if in default of such preventive measures a plague is well established, nothing short of systematic and vigorous poisoning will check it. This requires the employment of enough men to cover the infested areas in a reasonably short time.

In localities where mice are present in destructive numbers, systematic effort to control them results not only in considerable saving to the ranchman, but proves the best safeguard against more serious damage.

On the enormous ranches of the West, the centers of abundance which form the starting points for general invasions may develop on the lands of persons who neglect to control them. If each ranchman will consider the suppression of field mice on his own land a regular part of farming operations, such scourges of mice will never occur.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 353.

Experiment Station Work,

L.

Compiled from the Publications of the Agricultural Experiment Stations.

COMMERCIAL CLOVER SEED.
DODDER IN ALFALFA SEED.
GROWING POTATOES UNDER STRAW.
HENS VERSUS INCUBATORS.
PREPARING FOWLS FOR MARKET.
PRESERVATION OF EGGS.
THE MOUND-BUILDING PRAIRIE ANT.
COAGULATION OF MILK IN CHEESE MAKING.
EFFECT OF ALKALI ON CEMENT STRUCTURES.
SILO CONSTRUCTION.
A CHEAP AND EFFICIENT STERILIZER.
A CHEAP AND EFFICIENT ICE BOX.
THE POWER LAUNDRY FOR THE FARM.

JANUARY, 1909.

PREPARED IN THE OFFICE OF EXPERIMENT STATIONS.

A. C. TRUE, Director.

WASHINGTON:
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1909.

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EXPERIMENT STATION WORK.

Edited by W. H. Beal and the Staff of the Experiment Station Record.

Experiment Station Work is a subseries of brief popular bulletins compiled from the published reports of the agricultural experiment stations and kindred institutions in this and other countries. The chief object of these publications is to disseminate throughout the country information regarding experiments at the different experiment stations, and thus to acquaint farmers in a general way with the progress of agricultural investigation on its practical side. The results herein reported should for the most part be regarded as tentative and suggestive rather than conclusive. Further experiments may modify them, and experience alone can show how far they will be useful in actual practice. The work of the stations must not be depended upon to produce "rules for farming." How to apply the results of experiments to his own conditions will ever remain the problem of the individual farmer.—A. C. True, Director, Office of Experiment Stations.

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EXPERIMENT STATION WORK.[a]

COMMERCIAL CLOVER SEED.[b]

Clean soil and clean seed are essential to a clean crop. These requirements are especially necessary when the crop to be grown is of slow development in its earlier stages, as in the case of clover, alfalfa, and certain other, particularly the grass, crops. When land has been kept free from weeds and the seed bed carefully prepared it is readily realized how great a loss results when noxious weed seeds are introduced with the seed for a crop. As is pointed out by a recent bulletin of the Connecticut Station, there is frequently great danger of securing in the open market clover seed of poor quality, and the advice is given that purchasers make sure of the quality of the seed before buying. Of fifty-one samples of clover seed examined by this station three were heavily adulterated with black medic and only ten were apparently free from dodder, and two of these had a very low vitality. Only one-sixth of the entire number of samples analyzed was fit for use.

With reference to the weight of the samples, it is said that clover seed of average quality should weigh about 1.5 grams per 1,000 seeds, making about 302,000 seeds to the pound. Of the samples examined twenty-six did not reach this standard. Two weighed only 1.27 grams or less, equal to 363,000 seeds to the pound, while on the other hand two weighed 2.92 grams per 1,000 seeds, equal to 236,000 seeds per pound. Sowing a certain number of pounds of light seed per acre would put a greater number of seeds on the area than if the same quantity of heavy seed was sown, but under the same conditions the heavy seed would be more likely to give a satisfactory stand.

The vitality tests made under laboratory conditions showed an average vitality of 86.6 per cent for the fifty-one samples, or, in other words, an average of 86.6 out of every 100 clover seeds in the germination tests had life enough to produce a sprout. This result is regarded as satisfactory, although the vitality is but little above the provisional minimum of 85 per cent recommended by the seed laboratory of this Department for commercial clover seed. Twenty of the samples fell below 85 per cent, four below 75 per cent, and the lowest was 64.2 per cent.

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[a] A progress record of experimental inquiries, published without assumption of responsibility by the Department for the correctness of the facts and conclusions reported by the stations.

[b] Compiled from Connecticut State Sta. Bul. 160. See also U. S. Dept. Agr., Farmers' Bul. 79, p. 17.

The purity of clover seed is likely to be of greater importance than its weight or its vitality. While light or old and weak seed may be the cause of a partial failure of the crop, and generally does result in an imperfect stand, impure seed often produces a greater loss by noxious weeds introduced with it, and especially is this the case if it contains dodder, which often partly or entirely ruins a crop and which may stay in the land as long as the particular clover crop is grown on it. The average purity in this collection of samples was 90.5 per cent, or 7.5 per cent lower than the provisional standard of this Department, which is 98 per cent. The expression "98 per cent purity" means that of 100 pounds of seed bought 98 pounds are clover and the rest is dirt or foreign seeds. A botanical analysis of five samples showed the presence of at least thirty-five species of foreign seeds, including several kinds of dodder and total numbers of foreign seeds ranging from 12,458 to 78,604 per pound. Attention is called to the fact that if the foreign clover, alfalfa, and timothy seeds present, which range from about 2,500 to 35,000 per pound, are left out of account a seeding of 8 pounds per acre of any of these samples would plant from two to eight weed seeds on every square foot of ground.

Three samples of the lot were evidently adulterated. The first contained 21.2 per cent, the second 22.6 per cent, and the third as high as 39.1 per cent of black medic (*Medicago lupulina*), a leguminous plant of little or no value and apparently chiefly used for adulteration of red clover seed, the importations of which into this country frequently carry a very high percentage of this adulterant. The two kinds of seed are of about the same size and do not differ much in color, although black medic seed never has the purple or violet color of red clover seed. The medic seeds are also more oval in shape than those of red clover, which have a distorted heart shape, a roughly triangular outline with rounded corners.

The weed most dangerous and destructive to the clover crop is dodder, and the seed of this pest is about as large as small clover seed and very difficult to separate from it. In color it is light gray, yellowish or light brown, dull, finely roughened, but not pitted. Its method of attacking the clover plant is described as follows:

> The seed of this weed germinates in the ground, sends up a thread-like stem, yellow or reddish in color, which immediately attaches itself to its host plant. If it finds no plant on which it can feed, it dies, being entirely a parasite. Finding a suitable plant, it twines closely around the stem or leaf, sends its sucking organs into the tissue, and lives on its juices, weakening or killing the host. Its connection with the ground

soon ceases, and when actively growing the stem may be cut into any number of pieces, each of which, if attached to clover, will continue to flourish. It flowers and produces abundant seed, which stocks the ground for the next clover crop. Clover infested with dodder lodges, mats together, can not be properly cured, and either because of the dodder present or the molding of the clover in consequence, has been known to scour cows when fed out as hay.

In twenty-eight carefully tested samples from 18 to 11,615 dodder seeds were found per pound of clover seed. It is pointed out that a seeding of 8 pounds per acre of these two samples would place one seed to every 300 square feet and two seeds to every square foot of land, respectively. From alfalfa seed the dodder seed may be separated by sifting in sieves made for this particular purpose, but owing to the small size of red clover seed this method can not be applied in cleaning it from dodder.

DODDER IN ALFALFA SEED.[a]

The appearance of dodder in clover and alfalfa fields is generally most dangerous to the crop. The ordinary operations of mowing, raking, and hauling tend to spread this troublesome parasite, and with every new center of infection the chances of the crop grow less. A recent circular of the New York Experiment Station at Geneva describes the injury resulting from dodder in alfalfa fields as follows:

> Dodder is a yellow, thread-like twining weed which is exceedingly troublesome in alfalfa fields. It appears in circular spots 3 to 30 feet or more in diameter. At the center of the spot the alfalfa is killed out, while around the margin the ground is covered with a mat of yellow threads which twine closely about the stems of the alfalfa plants and slowly strangle them. The spots increase in size from year to year. Many fields have been completely ruined by dodder. It is not often injurious to other crops (except red clover), but once established in an alfalfa field it is very difficult to eradicate without killing the alfalfa.

As dodder is usually introduced with clover and alfalfa seed, the purchase and use of dodder-free seed can not be too strongly urged. Clean seed, however, can not always be secured, and therefore cleaning the seed is often necessary. Frequently neither the purchaser nor the seed dealer knows dodder seed, and consequently in many cases the first proof of its introduction is the appearance in the field of the weed itself. In view of these facts, the New York Station recommends that seed be examined before it is sown to determine the presence of dodder.

Alfalfa seed is larger than dodder seed and advantage was taken of this fact by the station to perfect a method by which commercial alfalfa seed may be made practically free from dodder and safe to sow. It was found that dodder seeds are readily removed by sifting through a wire sieve having 20 meshes to the inch. Since ready-made sieves of this mesh are not readily obtainable, it is advised to construct a light, wooden frame 12 inches square by 3 inches deep and tack over the bottom of it 20 by 20 mesh steel-wire cloth of No. 34 Washburn & Moen gauge wire. (Fig. 1.) This quantity of wire cloth ought not to cost more than 15 or 20 cents. In case brass or copper wire cloth is used the wire should be No. 32 on the English gauge. It is important that the wire cloth used be exactly 20 by 20 mesh, which may be determined by placing a ruler on the sieve or cloth and counting the number of spaces to the inch. With a sieve of this kind it is estimated that a man can clean from 3 to 7 bushels of alfalfa seed per day. From one-fourth to one-half pound of seed, and no more, should be put into the sieve at a time and vigorously shaken for one-half minute. To make the work uniformly thorough the use of a cup holding not over one-half pound of seed and careful timing of the sifting is recommended. If the seed contains but little dodder one sifting may do, but when much dodder is present, and particularly if it is of the large-seeded kind, two siftings, both made strictly as directed, are advised.

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[a] Compiled from N. Y. State Sta. Circ. 8.

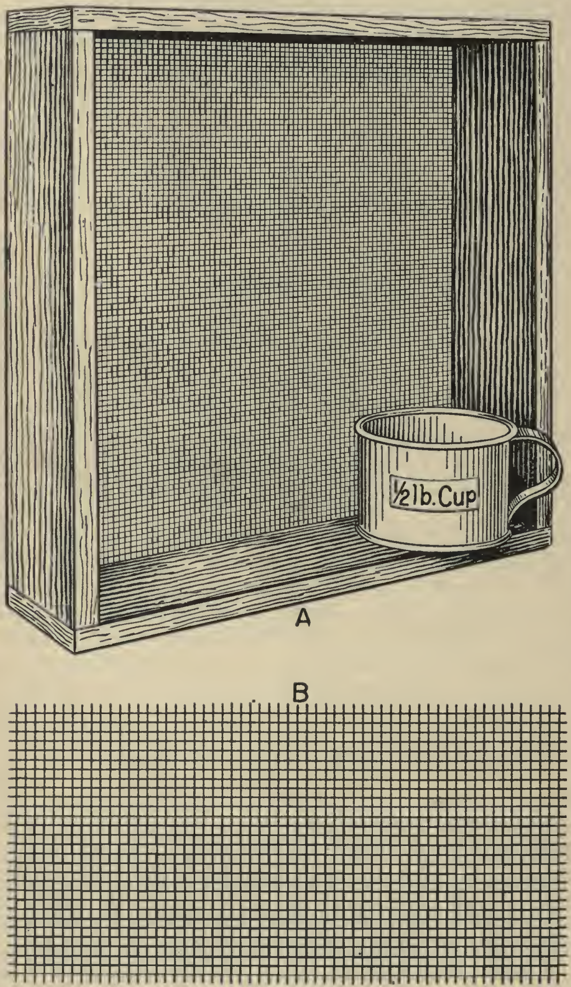

FIG. 1.—Tools required for sifting alfalfa seed to remove dodder seed: A, Home-made sieve 12 inches square by 3 inches deep; B, 20 by 20 mesh wire cloth made of No. 34 steel wire. (Natural size.)

In experimenting with this method it was observed that besides the dodder seeds various other small weed seeds, broken seeds, and dirt, as well as some of the smaller alfalfa seeds, were also removed by sifting. The siftings varied from about 1 to 5 pounds per bushel, according to the original cleanness of the seed and the thoroughness of the sifting. The rejection of the siftings is considered as causing but little if any loss.

GROWING POTATOES UNDER STRAW.[a]

In a previous bulletin of this series[b] attention was called to the good results obtained by R. A. Emerson, of the Nebraska Station, in growing seed potatoes under mulch. Seed so grown was found to be, under the warm dry summer conditions of Nebraska, much better than that produced by ordinary methods of culture. Mulching was also found as a rule to increase the yield, and the results in general indicate that while mulching would not be practical on a large scale, on account of the large amount of mulching material needed and the cost of application, it is entirely feasible on a small scale, as for instance, when the farmer raises a few potatoes for his own table or when he wishes to raise a few seed potatoes.

The practice has much to commend it in hot, dry climates, as the mulch conserves the soil moisture, but is not so successful in a wet season unless the ground selected is well drained. Another reason for the use of mulches is that it saves cultivation in the busy season, and in this respect early mulching is preferable to late mulching.

A writer in The Agricultural Gazette, of New South Wales, says:

> Perhaps no other field or garden crop is more benefited by a liberal mulch of wheat straw (or other litter) than potatoes, and especially is this the case with the second crop planted, say, in January. If the soil be well fined, the potatoes planted closely and covered shallow, and a mulch of from 1 to 3 or 4, or even 6 inches of straw applied immediately upon planting, good results are sure to follow. The potatoes will need no cultivation if the straw be applied at once before a packing rain. It prevents the packing of the soil by such a rain, breaking the force of the descending drops, and letting them down to seep slowly into the soil; and, intervening between soil and wind and sun, keeps it there, very largely, at least. It would be [a very] bad year if potatoes failed to do well under such treatment.
>
> If every farmer who grows wheat will try the following plan he will, in a figurative sense, convert his wheat straw into potatoes: As soon as the stripper has harvested the grain, mow the straw with mowing machine or scythe and rake into windrows, with horse rake or otherwise. Immediately plow and harrow the land between the windrows, and plant the potatoes in the usual way, only they may be planted in rows closer together than the usual distance, in order to economize the mulch. Plant in shallow furrows, and cover with the harrow, leaving the land perfectly level. Cover at once with the mulch of straw to whatever thickness you have straw sufficient for, and the work is done. The potatoes will come up through the straw and flourish, and never be troubled by weeds. No further cultivation will be necessary. When the potatoes are gathered, many fine tubers will be found, not only in the soil and near the surface, but lying on the top of the ground just under the straw. * * *

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[a] Compiled from Nebraska Sta. Bul. 97; Agr. Gaz. N. S. Wales, 11 (1900), No. 1, pp. 46, 47; 19 (1908), No. 3, p. 104.

[b] U. S. Dept. Agr., Farmers' Bul. 305, p. 8.

> If wheat straw is not available for mulching potatoes, bushes, suckers, and green branches from trees laid thickly over the whole surface of the soil will be found a very good substitute.

It is to be noticed that the above was written for a country that is subject to periods of drought; also that January there corresponds to July in this hemisphere.

Another writer in the same journal describes an extreme type of the mulch method of growing potatoes, which may be used on heavy stiff lands not suited to potatoes, as follows:

> The ground is plowed deeply and harrowed into a good state of tilth; the potatoes are then placed by hand firmly in the soil until they are about half covered; then 12 to 15 inches of wheaten straw is placed over them; this completes the planting. Nothing more is done until the potatoes are picked—not dug—from under the straw, for they lie on top of the ground around the seed set. * * * The straw forms a protection from the sun and other destructive agents, the same as the earth does when they are grown in the ordinary way.

This method of course commends itself only for small scale garden operations, but certainly has the advantages of ease and simplicity. Potatoes so grown can be easily removed from the hill from time to time as they mature.

A method of this kind has been used to some extent in certain parts of this country, where it is known as the "lazy bed." While convenient and economical of labor, it of course is not to be recommended except where better methods of culture are not feasible.

HENS VERSUS INCUBATORS.[a]

The question of the relative merits of hens and incubators as a means of hatching chickens is of much importance to all who raise poultry on a scale at all extensive.

The person who raises only a small number of chickens will, as a rule, do better to use hens for hatching purposes, while the commercial poultryman, who must be able to have stock ready for market at different times, is practically compelled to use incubators. However, all studies of the relative efficiency of the two methods of hatching are of value since they may point the way for improvement in the artificial method of incubation, bringing it gradually nearer in results to the natural method.

The Oregon Station has recently made studies of various problems of incubation, and the results bearing on relative efficiency of hens and incubators are summarized as follows:

> (1) From 879 eggs set, incubators hatched 533 chicks, or 60.6 per cent.
> (2) From 279 eggs, hens hatched 219 chicks, or 78.8 per cent.
> (3) Eliminating eggs broken in nests, the hens hatched 88.2 per cent of eggs set.
> (4) The incubators hatched 78.5 per cent of "fertile" eggs, and the hens hatched 96.5 per cent.

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[a] Compiled from Oregon Sta. Bul. 100.

(5) Eggs incubated artificially tested out 22.7 per cent as infertile, while those incubated by hens tested out 11.8 per cent.

(6) The incubators showed 16.6 per cent of chicks "dead in the shell," and the hens 2.8 per cent.

(7) Chicks hatched under hens weighed heavier than chicks hatched in incubators.

(8) The mortality of hen-hatched chicks brooded in brooders was 10.8 per cent in four weeks, and of incubator-hatched chicks 33.5 per cent.

(9) The mortality in hen-hatched chicks brooded under hens was 2.2 per cent, and of incubator chicks 49.2 per cent.

(10) In other tests the mortality was 46.5 per cent for incubator chicks brooded by hens and 58.4 brooded in brooders.

(11) Hen-hatched chicks made greater gain in weight than incubator chicks, whether brooded by hens or brooders.

From these results Professor Dryden concludes that hens were more efficient hatchers than the incubators, though the incubators hatched a fairly satisfactory number of the eggs.

It may be true in practice that the incubator will hatch as many chicks, on the average, as the sitting hen, because the hen sometimes breaks eggs in the nest and sometimes quits her job, two things that the incubator is not guilty of, though occasionally the lamp will go out, the temperature will go wrong, and all the eggs will be spoiled. But this is a matter of care with the operator, and with fair care the loss from accidents will be less in the incubators than under hens. It may therefore be that an incubator properly attended will, on the average, hatch as many chicks from a certain number of eggs as a certain number of hens will hatch from the same number of eggs of the same kind.

Successful incubation, however, does not mean merely the hatching of a large percentage or a certain percentage of the eggs; the serious problem is not how to hatch the greatest percentage of the eggs, but it is rather how to hatch the largest number of chicks of greatest vitality. The test of the incubator is not that it hatch, on the average, as large a percentage of the eggs as the sitting hen, but that it hatch as many and as good chicks as a good sitting hen. Until this can be done poultry enterprises will continue to lag where artificial methods of incubation are used.

On the whole the results show that artificial incubation is responsible for the large percentage of chicks "dead in the shell," as well as for the large mortality of chicks in the brooder. There are doubtless brooder problems affecting the vitality of the chick, but this fact should not obscure the plain demerits of artificial incubation. * * *

That the incubator is the cause of the mortality in the chicks was demonstrated in two ways: First, when hen-hatched chicks and incubator-hatched chicks were put together in the same brooder, the former lived well and the latter showed a large death rate; and, second, it was demonstrated when hen-hatched chicks and incubator-hatched chicks were put together with the same hen or hens, the former lived well and the latter showed the usual mortality, or practically so.

In considering the relative profitableness of the two methods, account should also be taken of the relative cost of labor.

The figures given above show that there was a marked difference in weight of hen-hatched and incubator-hatched chicks. While the cause of this difference was not definitely determined in these experiments, it was found that the adding of moisture to the incubators increased the weight of the chick. Professor Dryden is of the opinion, however, that it is not a question of moisture alone, because he found "that by increasing the moisture in incubators to such an extent that the eggs lost less weight than eggs under hens normally, the incubator chicks weighed less than the hen chicks, though the moisture increased the weight of the incubator chicks."

The proper handling of incubators is fully discussed in a Farmers' Bulletin of this Department.[a]

PREPARING FOWLS FOR MARKET.[b]

In continuation of his suggestions to amateur poultrymen previously noted,[c] C. K. Graham in a recent bulletin of the Connecticut Storrs Station gives directions for preparing fowls for the market. He states that "the method of killing not only affects the plucking of the fowl, but will to a large degree affect the quality of the flesh."

Chickens should not be chased or excited before killing, as this is thought to have an unfavorable effect on the flavor and texture of the flesh. To avoid this it is well to have a catching hook such as is described in a former bulletin of this series.[d] The best method of killing is probably by bleeding, and is described as follows:

> Hold the head of the bird with the left hand, back of the head up, keeping the hand on the back of the neck to avoid cutting yourself should the knife slip and pass through the top of the head. Take the knife in the right hand, the back of the blade toward your body. Insert the blade in the mouth, keeping the point to the right side of the bird's neck and as near the outer skin as possible until it is well past the neck bone. Then press the edge toward the bone and slowly draw the knife from the mouth, the hand moving from your body, so that the knife appears to pass across the neck. Repeat the process on the left side of the neck. This should cause the bird to bleed freely, but by holding the beak up the blood will remain in the neck, giving you plenty of time to pierce the brain. The latter is located just above the eye and can be easily reached through the upper part of the mouth by using a stiff steel blade, inserted in the mouth with blade edge up and pointing slightly over the eye. With young birds little trouble is experienced in piercing the brain, but with older birds a very stiff blade is required, as the bones are much harder. When the point of the blade enters the brain, give the knife a quick twist to right or left to widen the aperture. If the brain has been reached, the bird will attempt to squawk or will give a nervous jerk as the blade touches the spot, and this touching the brain or nerves not only loosens the feathers of the bird for dry plucking, but will greatly improve the appearance of scalded stock.

A weight, which may consist of an old tomato can half filled with stones and cement, is immediately attached by means of a wire hook to the lower mandible of the bird. "Then by grasping the wings close to the back, the bird will not be able to flutter, and can be easily and rapidly plucked. This, of course, should always be done while the bird is bleeding. * * * The can catches the blood, and by hanging the bird over a barrel the feathers may easily be saved."

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[a] U. S. Dept. Agr., Farmers' Bul. 236.

[b] Compiled from Connecticut Storrs Sta. Bul. 52.

[c] U. S. Dept. Agr., Farmers' Bul. 237, p. 22.

[d] U. S. Dept. Agr., Farmers' Bul. 317, p. 31.

Since there is considerable difficulty in scalding birds properly and it is often improperly done, dealers usually pay a little more for dry-plucked birds.

The breast should be plucked first, starting near the crop. After the breast the thighs, then the back near the base of the tail, and last the wings. As soon as the feathers have been removed the wings should be twisted over the back and the bird taken from the hooks and the feet washed, after which the thighs and legs should be pressed to the body either by placing a brick on the bird's breast or by tying the body, the object of this being to give the bird a plump or blocky appearance.

The birds should not be allowed to hang until they become rigid, as that causes them to look thin. Care must be taken that all animal heat has left the birds before they are packed for shipment, but this does not mean that it is necessary for them to hang while cooling.

As a rule, the head and feet are left on and the entrails are not removed, but such details depend on the requirements of the market to which the birds are sent. The following directions are given for preparing drawn poultry:

Broilers.—Lay the bird on its side, draw the knife down the back, beginning between the shoulders near the neck, and cut through the backbone or along each side and remove the bone. Continue cutting past the oil sack and tail around to the end of the breastbone, then lay the bird on its breast. The entrails can then be easily removed, and the blood, if any, wiped out with a dry cloth.

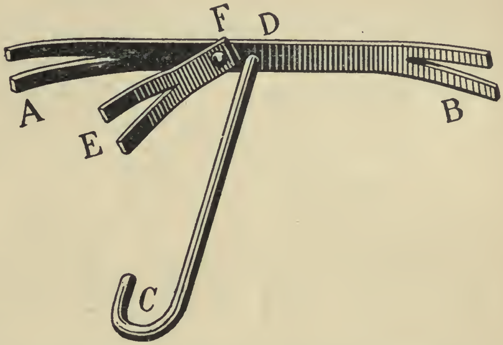

FIG. 2.—Hook used at Storrs Experiment Station to hold birds for plucking: A-B, bar; C-D, staff; E-F, arm.

Roasters.—Place the bird on its breast, head down. Inserting the point of the knife in the back just between the shoulder blades, continue the cut along the back of the neck to the head. Near where the blade first cut the skin will be noticed a white spot, which marks the joining of the neck to the backbone. By a little manipulation with the point of the blade the neck bone can be easily severed at this point. The aesophagus and wind pipe should then be separated from the skin of the neck, after which the head may be removed, making the separation from the skin of the neck as near the head as possible. The crop is then easily removed, and after being severed from the entrails, the latter, including the lungs, should be loosened from the frame of the bird by inserting the finger in this opening. The bird should then be placed with the vent up. Hold the vent with the left hand and cut around it, and in doing so loosen the main gut from the back of the fowl. In this way the entrails can be removed with little or no dirt, and through a very small opening.

Many consumers object to a roasted fowl on which the flesh has been drawn off the bones at the knee joints. This can be overcome by leaving a little of the yellow scale or shank on the back of the leg at the knee when removing the shanks.

All birds intended for roasting should have the sinews of the leg removed. To do this cut the skin of the shank lengthwise just back of the bone. With an eight-inch screw-driver raise the sinews, and by a twist of the tool these may be parted. They can then be pulled easily by holding the leg and screw-driver as you would a bottle and corkscrew.

A convenient hook for holding fowls for plucking is shown in figure 2. The bar A–B is of quarter-inch iron 1 inch wide and 18 inches long, with a split 3 inches long and about three-fourths of an inch wide at each end. A 5-inch arm E–F is riveted to A–B 1½ inches from D, making the distance from B to E about 15 inches and providing for fowls too small to spread from A to B. The staff C–D is of half-inch round iron 18 inches long with a shoulder at D and riveted on the under side of A–B, so that the latter will swing freely.

PRESERVATION OF EGGS.[a]

The best means of preserving eggs, particularly methods in which water glass is used, have been discussed in several earlier bulletins of this series,[b] and much has been written on this subject, but the question of securing eggs in the best possible condition for preservation has heretofore received little attention. G. H. Lamson, jr., of the Storrs Experiment Station, has, however, recently reported investigations on the causes and sources of infection which may result in the spoiling of eggs and on the best practical means of securing clean, sound eggs for preservation in water glass.

It was found that eggs may be infected with the bacteria of decay in the oviduct before the egg is laid, and through pores and defects in the shell after the egg is laid. Much can be done to reduce the chances of infection and to reduce or prevent the injurious effects of infection, thereby greatly improving the keeping quality of the eggs. In the first place the hens should be kept in as nearly perfect health as possible and should be given enough shell-forming food to enable them to make strong shells of uniform thickness.[c] Clean nesting places are necessary to prevent infection in the nest. The eggs should be gathered daily and kept in a dry, cool room or cellar where the sun's rays do not fall directly upon them. Only clean eggs should be used for preservation and these should be placed in the preservative within twenty-four hours after they are laid.

Eggs laid during April, May, and early June were found to keep better than those laid at any other season. It is recommended, therefore, that only eggs laid at this season be preserved. It was found that water glass when properly made seals the eggs to prevent further infection and when kept at a comparatively low temperature prevents the multiplication of bacteria (decay) within the egg. Water glass can usually be obtained through druggists at from $1 to $1.25 per gallon, a gallon of the water glass being made into 10 gallons of preservative by simply dissolving it in 9 gallons of water which has been boiled and cooled before use.

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[a] Compiled from Connecticut Storrs Sta. Bul. 55.

[b] U. S. Dept. Agr., Farmers' Bul. 296, p. 29.

[c] U. S. Dept. Agr., Farmers' Buls. 186, p. 26; 225, p. 26.

The preserved eggs should be kept in a cellar or room of even temperature which does not go over 60° F.

If care is taken to select clean, sound eggs, and proper precautions are observed in carrying out the details of the method of preservation as above indicated, it is believed that water glass furnishes a cheap, reliable, and easily employed preservative for domestic use, "and by its use everyone having a supply of fresh eggs in the spring can make a considerable saving; and at the same time have a larger number of fresh eggs to use in the winter."

THE MOUND-BUILDING PRAIRIE ANT.[a]

In a recent bulletin of the Kansas Station, T. J. Headlee and G. A. Dean describe the prairie ant and the mounds they build and discuss their economic importance from an agricultural standpoint. It is shown that "while it is true that they destroy a small percentage of cultivated crops, their substantial claim to the title of injurious insects lies in the annoyance caused the farmer in cultivating and harvesting his crops and in the discomfort resulting from their efforts to protect their habitations when occupying public streets, sidewalks, much-used paths, dooryards, and corrals."

The ant mounds are found throughout western Kansas and the neighboring States, comprising the Western plains. They are sometimes circular, but usually elliptical at the base, and are from 2 to 6 feet in diameter and vary in height from a few inches to as much as 2 feet. The ants clear a circular space around their mounds, removing all vegetation from it to a distance of 5 to 10 feet from the mound on all sides; the mound is usually exactly in the center of the cleared space. The outside of the mounds is covered with gravel or other coarse material that may be at hand, such as cinders, bits of coal, and the like. This covering is from one-half to 1 inch deep, and the sides of the mound are made as steep as the covering material will allow.

The mounds have from one to three funnel-shaped openings, and in a few cases a still larger number, through which the workers pass in and out. The large end of the opening is toward the outside, and the openings are commonly about one-third the distance from the base to the top of the mound. These openings are closed about sunset or during the day at the approach of a storm and opened in the morning about 8 or 9 o'clock in summer. The closing is done so well that a very close examination is necessary to determine where the openings have been.

On hot days in summer the workers return to the mound before noon and remain inside during the hottest part of the day, but on cool days the entire day is spent outside.

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[a] Compiled from Kansas Sta. Bul. 154.

Under the coarse covering of the mound is a rain-proof roof made of particles of soil cemented together. Beneath this the mound and the soil directly under it to a great depth is honeycombed with circular chambers from 1 to 3 inches across and from one-half to 1 inch high. These chambers are connected by galleries about three-eighths of an inch in diameter and of various lengths. Some of these chambers are filled with seeds of any kind that are small enough for the ants to carry and that are near to the mound; other chambers are occupied by the young in various stages of growth; and still others serve as rooms for the adult ants.

The ants are of three classes—males, fertile females, and sterile females; the latter is the working class and is by far the most numerous. It is estimated that large colonies may have 10,000 workers. The ants vary in length from three-sixteenths to seven-sixteenths of an inch. All the females have large mandibles and stings.

These ants are not pests in the usual sense of the word; as long as the country which they inhabit was sparsely settled they did no harm. Since the country has become more thickly settled, so that they come into close contact with man, they have become a source of annoyance.

The ant colonies are usually too scattering materially to decrease the yield of any important crop. Even in alfalfa, where the damage occasions most complaint, they are chiefly troublesome as an obstacle to harvesting. In a 7½ acre field at Hays City, Kans., thirty-four colonies had cleared a space amounting to between 1 and 2 per cent of the total area, and most of them had constructed mounds of sufficient size to compel the mowing machine to pull around them. To attempt to mow through or over them would have choked the machinery and ruined the cutting edge of the sickle. Should a driver have such trouble in passing over a mound it would be most unwise for him to stop and try to adjust his machinery, for such a disturbance would bring the ants forth in angry swarms, each individual eager to do her utmost to repel the invader. Every one that succeeded in getting on man or beast would seize clothing, hair, or skin between her mandibles, curve her abdomen downward, and deliver a thrust quite as painful in result as the sting of bumblebee or yellow jacket.

Even if the mounds be leveled some days before the cutting, the difficulty is merely lessened, for the passage of the team and machine over the nest is sufficient to bring the ants out in readiness to attack when the intruder comes around again. To a less degree the same difficulty is experienced in raking and loading the hay.

In the dooryard the ants not only render the lawn unsightly with their mounds but unhesitatingly attack the careless child who walks over or plays about their nest. In trodden paths the passage of man or beast is sufficient to bring them out ready for any unfortunate that may follow soon after, and in corrals their determination to defend their rights is a source of annoyance to stock.

The authors' study has failed to find any effective natural enemy of the ants, and a trial of various methods of killing them shows that fumigation with carbon bisulphid is the most satisfactory. The method is described as follows:

Carbon bisulphid is evaporated under a practically air-tight vessel over one or more of the opened gateways of the mound. The vapor formed, being heavier than air, sinks downward through the burrows into the lowest parts of the nest and finally comes to fill every chamber and passageway. Thus all the ants that are at home are suffocated. Many nests so treated were carefully opened to the lowest chambers and all the occupants found dead beyond possibility of doubt. Some nests were not opened until the next day after the fumigation and then not a living ant could be found. The following method of using carbon bisulphid has proven the easiest and most efficient tried. Start fumigation when gateways are open; take a vessel, such as a galvanized-iron washtub, and place it bottom side up in such a manner as to cover the openings and as much of the mound as possible; if there are more openings than the tub will cover they should be closed by throwing some of the surrounding soil over them; place under the tub, in a shallow pan or dish, near the opening, 1 to 3 ounces of carbon bisulphid, depending on the size of the nest; quickly pack soil around the edge of the tub, making it as nearly air-tight as possible; allow to stand thus for about five hours. The experiments show that breaking open the mound before setting the fumigation is of no advantage, nor did the practice of pouring the fluid into the broken-up mound give any better results than that of evaporating it from a shallow pan.

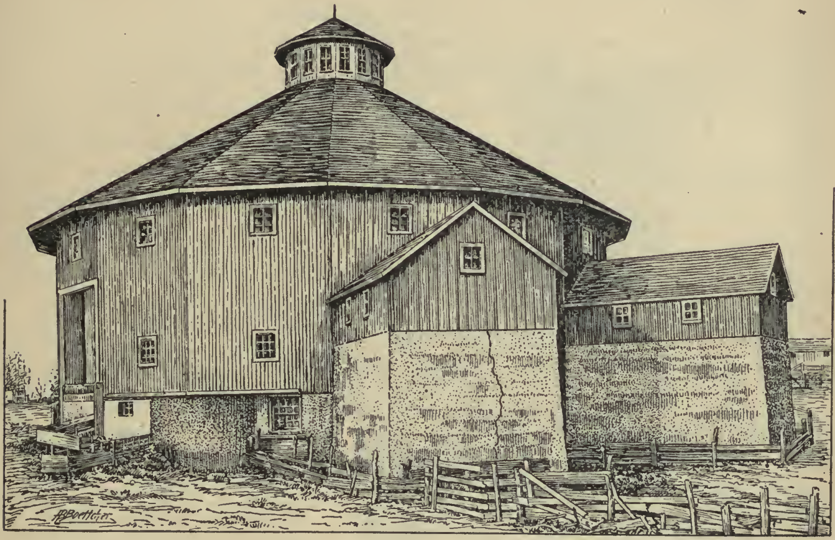

FIG. 3.—Square cement silos connected with barn. Not proper shape and too shallow.

It should be noted that carbon bisulphid is explosive and care should be observed in its use.

Since the reproducing members of the colony remain in the mound at all times, the above method would seem to be all that could be desired.

EFFECT OF GLASS, METALS, ETC., ON COAGULATION OF MILK IN CHEESE MAKING.[a]

One important problem with which the cheese maker has to deal is the irregularity in the coagulation of milk with rennet. This irregularity may be traced to a number of sources, such as variation in the strength of rennet extract used, the quality of the milk, and the kind of utensil employed. Experiments were made by G. A. Olson, of the

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[a] Compiled from Wisconsin Sta. Rpt. 1907, p. 134; Bul. 162.

Wisconsin Station, to discover the effect of different metals (platinum, tin, copper, nickel, iron, aluminum, and zinc) as compared with glass on the length of the coagulation period. "The experiments were conducted by placing milk in contact with [the] various metals for definite periods of time and afterwards observing the time required for the coagulation of such milk, with a standard solution of rennet, under uniform conditions." It was found that with the single exception of aluminum each of the metals tried produced a prejudicial (retarding) influence on the rennet action. The most striking influence observed was in the case of milk in contact with pure nickel. Milk which had stood in contact with this metal for twenty-five hours at 87° F. required four hundred and twenty minutes for coagulation with rennet and showed an acidity of 0.167 per cent. Under the same conditions milk in contact with glass required only nineteen minutes for rennet coagulation and showed an acidity of 0.207 per cent. However, as milk is hardly ever kept in nickel or nickel-plated utensils, the retarding effect of this metal has little significance from a practical standpoint. Copper also exerted a decidedly retarding effect, and as this metal is used more or less extensively in the form of heating disks in continuous pasteurizers in creameries and as kettles in the Swiss cheese factories, its retarding action is a matter of more practical importance. Apparently glass exerted a more or less accelerating influence on rennet coagulation and was to this extent beneficial in action. The degree of effect was directly dependent upon the character of the glass.

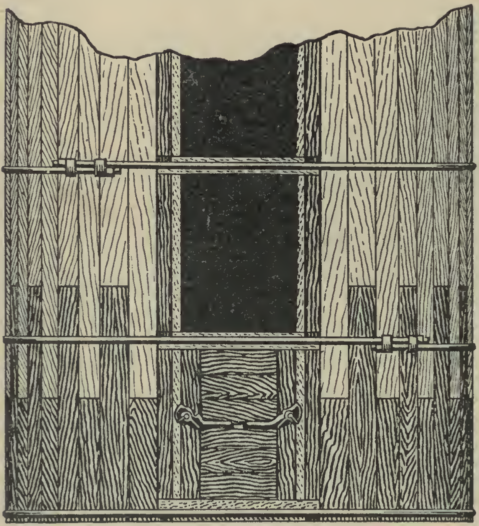

FIG. 4.—A silo with redwood staves at the bottom; cheaper wood above.

THE EFFECT OF RUSTY MILK CANS.

The experiments referred to above showed that both tin and iron have a prejudicial influence on rennet action. This suggested the desirability of determining whether or not rusty cans have a similar influence. Part of a sample of milk was placed in a rusty tin pan (with about fifteen rust spots in the bottom of the pan) and the remainder was kept in a Jena glass vessel (beaker) for comparative purposes. The milk kept in the rusty pan gave evidence of a retarding influence on the rennet action as compared with that kept in the glass beaker. "It required from one to sixteen and one-half minutes longer for the same milk kept in the rusty pan to coagulate than in case of the milk kept in the glass beaker." Wherever there was a retarding influence on the rennet action there was also a retardation of the acid development as well, but the latter was not sufficient to account for the delayed rennet action.

Milk which had been allowed to stand in iron dishes for several hours had a peculiar bluish gray color, indicating the presence of iron in solution. In several instances the amount of iron dissolved in the milk was determined as iron oxid. The maximum quantities of iron dissolved in the milk ranged from 1 to 1½ pounds for every 1,000 pounds of milk. The lower acidity of the milk kept in contact with iron also supports the view that the acid of the milk acts upon the iron and finally causes it to pass into solution [retarding rennet action].

Milk comes in contact with iron in the form of rusty cans or poorly tinned utensils in practically all creameries and cheese factories. The quality of the milk will to a large extent depend upon the condition of utensils into which the milk is poured, kept, and finally hauled to the factory. The degree of influence of iron on milk will depend largely upon the temperature of the milk, the length of time kept in the cans, and the amount of exposed surface.

Conditions in north European dairy countries.—In progressive dairy countries of northern Europe the quality of dairy products manufactured is generally uniform, and every precaution is taken to maintain a uniform product. Cleanliness is generally practiced at both the farm and factory. The utensils used are of superior quality, and naturally there is no occasion to consider this problem seriously. As a rule, the European utensils are stronger; the cans, for example, are of heavy steel and well tinned. Experience shows that these heavy cans are the most economical in the long run, and there is less danger of denting in or wearing off of the tin.

Conditions in America.—It is not necessary to describe here the American milk can, and especially the cheaper ones; if not the first time, surely the second or third time these cans are used one will find places where they have been dented in. As the number of indentations increase the tin begins to crack, leaving fissures or inroads for milk and water and acid. Often this thin layer of tin does not cover all of the iron, thus leaving microscopically small surfaces of iron exposed, which also become the sources of damage by water and acid. Under such conditions the tin peels or falls off, and it is then only a short time before the cans become unfit for use.

The attention of the milk producer and the factory operator is called especially to the following points:

(1) A better grade of utensils should be used in the handling of milk and its products. The iron or steel plate should be heavier and more thickly coated with tin.

(2) No milk should be accepted at a factory which has been kept in iron exposed pails or cans.

(3) The factory or creamery should be an example of neatness and cleanliness, with all utensils in first-class condition.

(4) Cooperation among the proprietors of creameries, cheese factories, and city milk supplies will tend to bring about cleanliness among patrons and the use of better utensils.

(5) Milk should be bought on its merits, by some satisfactory arrangement following well-founded sanitary and hygienic rules, by which the production of milk of superior quality is encouraged and milk of low grade either rejected or gradually improved.

THE EFFECT OF ALKALI ON CEMENT STRUCTURES.[a]

E. T. Tannatt, of the Montana Station, and W. P. Headden, of the Colorado Station, have recently called attention to certain facts observed in the course of their investigations which have a very important bearing on the use of cement in farm structures, a use which has rapidly grown with the increasing scarcity and advancing price of timber, viz, the action of alkali on the cement used in concrete structures.

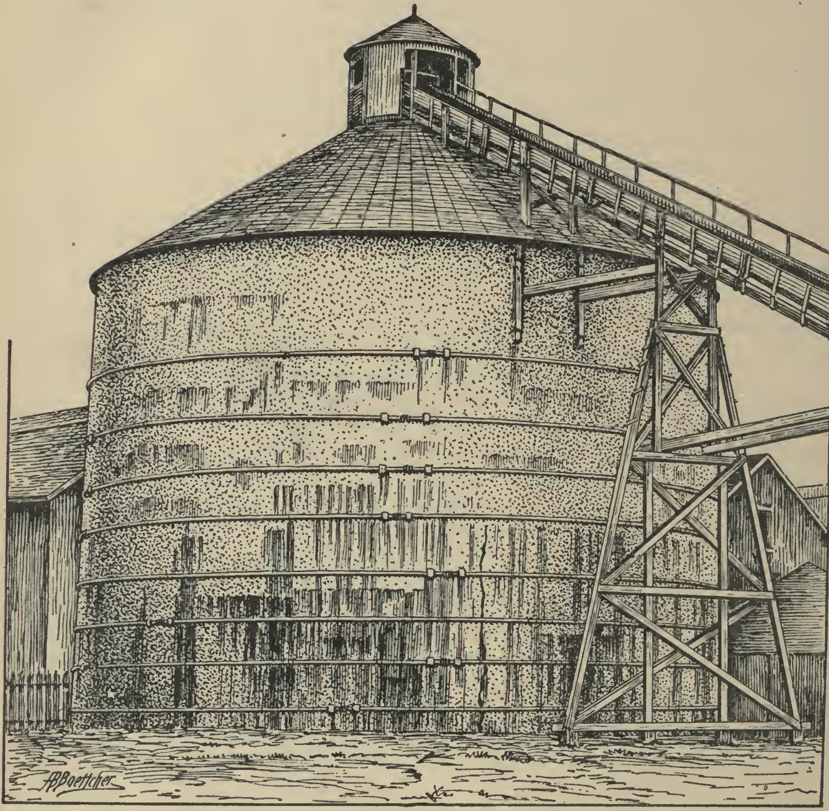

FIG. 5.—A large concrete silo which failed.

Professor Tannatt says.

> Cement is being generally used for the construction of culverts, flumes, bridges, foundations, retaining walls, curbings, etc. It has also been largely used in various parts of the canals, conduits, dams, etc., constructed by the United States Reclamation Service on their irrigation projects. A large number of the private irrigation and drainage projects of the West also make use of cement construction to a large extent. Conditions are pointing to a more general and larger use of cement in the structural works of the future. This material is also becoming more and more generally used in agricultural construction. In fact, it is difficult to prophesy to what extent cement may enter into the development of the resources of the country.

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[a] Compiled from Montana Sta. Bul. 69 and Colorado Sta. Bul. 132.

Professor Tannatt cites a number of cases of weakening or breaking down of cement structures due to the action of alkali. As "the distribution of alkali is quite general, being found throughout the arid and semiarid regions of the Western States and in the Great Central Basin," the damage which may result from this cause is of grave importance.

The examinations and chemical analyses (of a cement sewer) reported show that "the amount of disintegration corresponds closely to the percentage of alkali present." It was also found that sandstone is subject to similar disintegration under the influence of alkali. For this reason Professor Tannatt is of the opinion "that the use of sandstone in foundations, and for a couple of feet above the surface, is very inadvisable in the alkali sections."

As means of protection of foundations against the action of alkali it is suggested that—

> The ground on the exterior side should be excavated to the bottom of the foundation, the surface of the sandstone should be thoroughly cleaned with steel brushes and washed. Where the cement mortar shows signs of disintegration, the same should be removed and replaced with new material. After the surface of the foundation has been cleaned, the same should be given a good coat of hot asphalt, the coat extending sufficiently above the surface to include the alkali limit [2 feet above the surface]. In the bottom of the trench thus made along the foundation, a small tile should be laid which will drain any water away from the foundation, or into the city sewer. The trench, at least a portion along the face of the foundation, should be back filled with clean gravel or crushed rock to within a foot or so of the surface of the ground; above this may be placed earth for lawn, if desired.
>
> Concrete foundations for buildings are being used very extensively. Where any large amount of alkali is present in the soil, we believe that cement should not be used, unless thoroughly protected from the action of the alkali salts. This should be accomplished by thorough and proper drainage, and the use of some method similar to that suggested for sandstone foundations.

Professor Tannatt also calls attention to the possibility of harmful action of alkali in the case of cement sidewalks.

> In the construction of cement walks in the alkali sections, we would recommend that special care be taken to use clean gravel or broken stone. The use of soil in foundation gravel will furnish a means of bringing the alkali in contact with the lower portions of the cement. It is also advisable, we believe, that where the gravel or broken stone foundation is liable to become filled with water, to place a small drainpipe discharging into the gutter. We feel that with the present knowledge of the situation too much care can not be taken to prevent the alkali coming in contact with cement construction, either through the agency of standing water or the capillary action of the soil.
>
> The general recommendation is made that wherever cement construction is used in the alkali sections, a mortar made of granular sand should be used, and the mortar should be of maximum density.

SILO CONSTRUCTION.[a]

The general subject of silos and silage has been fully discussed in previous Farmers' Bulletins.[b] It is the purpose in this article, mainly on the basis of data reported by a number of the experiment stations, to point out some faults of silo construction which more extended experience has revealed, and to indicate, if possible, how these faults may be corrected and the general construction of silos improved, for, while it is generally conceded, by dairymen particularly, that the silo has become a necessity, occasional silo failures have discouraged the use of silage to some extent.

FAILURES OF SILOS.

Some of the failures of silos have been due to carelessness in filling, but more frequently to faulty construction of the silo.

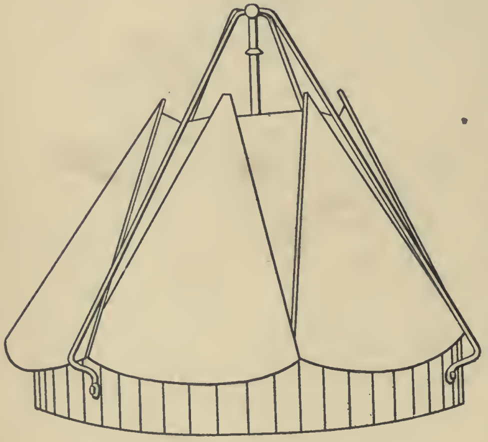

FIG. 6.—The patent roof of a silo, open.

Formerly many silos were made by sheathing one of the bays in the barn. With these silos and other forms of wooden square silos a lining must be built across the corners and the silage well tramped down along the edges or there will be considerable loss of what would otherwise be valuable stock feed. This style of silo, however, has become less common, and but few square silos of any kind are built at the present time. Even when silos are built inside of a barn they are often circular. Figure 3 shows a square silo that can not be recommended, not only because it is square but because it is not deep enough. The octagon silo is an improvement over the square form, but as a rule the walls of this form of silo have not been made rigid enough. The details for constructing the octagon silo were given in a previous Farmers' Bulletin.[c]

Too often the walls of silos are not made air-tight. Unless the walls of wooden silos are made air-tight, with tar paper, felt pads, or clay worked into the joints, much silage will be wasted. Ninety per cent of stave silos are not air-tight at the foundation. The shrinkage and swelling of staves breaks the cement, which must be frequently mended. Some losses have occurred because the ends of the staves have decayed. Figure 4 shows how some durable wood may be used at the bottom of the silo, which is one method of overcoming this difficulty. The iron bands of the stave silo must frequently be examined, or they will fall down as the staves shrink. Sometimes the iron splices rust. Unless a stave silo is well anchored it may be moved from its foundations or even blown down. A further discussion of the stave silo may be found in a previous Farmers' Bulletin.[a]

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[a] Compiled from Illinois Sta. Bul. 102; Iowa Sta. Bul. 100; Maryland Sta. Bul. 129; Wisconsin Sta. Bul. 125.

[b] U. S. Dept. Agr., Farmers' Buls. 32, 292.

[c] U. S. Dept. Agr., Farmers' Bul. 190, p. 21.

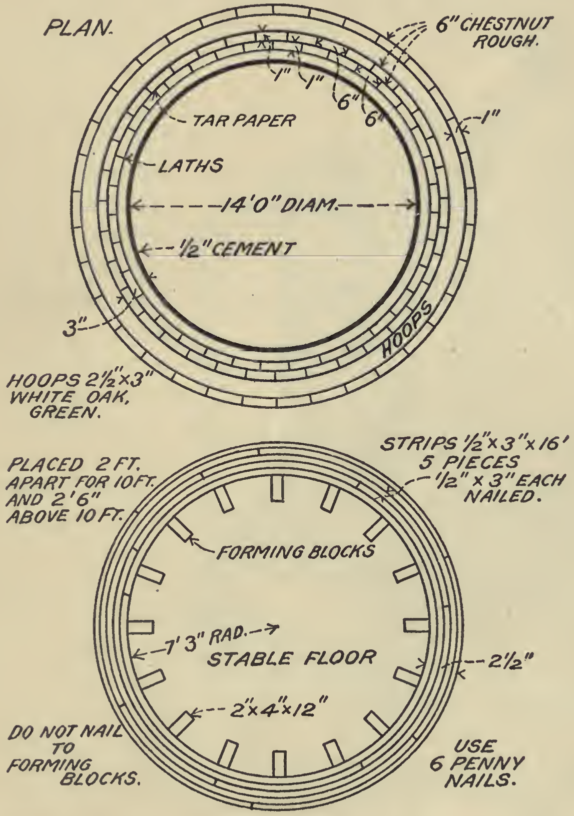
PLAN.
6" CHESTNUT ROUGH.
1"
1"
6"
6"
1"
TAR PAPER
LATHS
14'0" DIAM.
½" CEMENT
3"
HOOPS
HOOPS 2½"×3" WHITE OAK, GREEN.
STRIPS ½"×3"×16' 5 PIECES ½"×3" EACH NAILED.
PLACED 2 FT. APART FOR 10 FT. AND 2'6" ABOVE 10 FT.
FORMING BLOCKS
7'3" RAD.
STABLE FLOOR
2½"
2"×4"×12"
DO NOT NAIL TO FORMING BLOCKS.
USE 6 PENNY NAILS.

FIG. 7.—Showing method of making hoops and details of the construction of a stone and stave silo.

The walls of the silo must be rigid or they can not stand the pressure. Figure 5 is an illustration of a silo, the concrete walls of which were not rigid enough to withstand the inside pressure. When the sides begin to bulge, air can get between the silage and the walls. Brick silos without reinforcement have been failures because of this pressure from the inside.

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[a] U. S. Dept. Agr., Farmers' Bul. 103, p. 23.

A mistake sometimes made was in building the silo of too large a diameter for the size of the herd, so that the silage spoiled by too long exposure of the surface. In one case a man with a small herd built a silo in his barn 18 feet square and 16 feet high. After two years' trial he gave up the use of the silo in disgust because his silage did not keep. A year or two later he sold his farm to a more progressive man, who built partitions across the same silo, making four small silos out of the large one, and had no difficulty in obtaining good silage for stock. The silos should be deep. The deeper the silo the better the silage. The diameter should conform to the size of the herd, and if 2 inches of silage are fed each day there will be no loss from surface exposure.

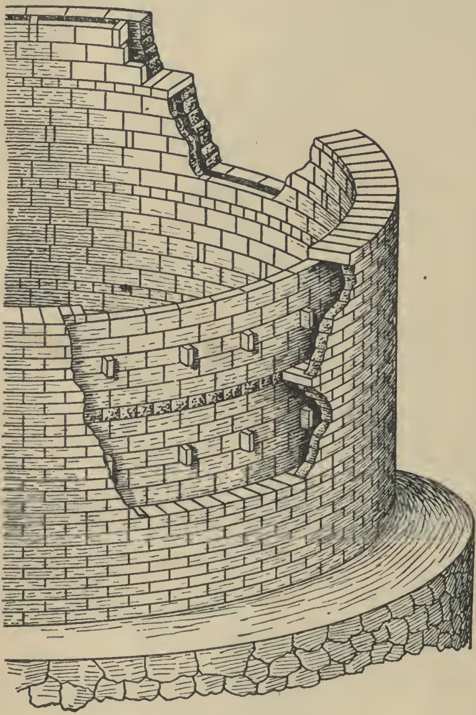

FIG. 8.—Double wall brick silo.

It is desirable to prevent silage from freezing. The double wall concrete silo and those built of rectangular building tile accomplish this object as well as any. Stone silos prevent freezing, but many owners of stone silos do not like them because moisture collects on the inside of the walls and rots the silage along the edge. A roof helps to keep out the frost, rain, and snow. Figure 6 shows a patent roof which allows the silo to be filled above the top.

MATERIALS FOR SILO CONSTRUCTION.

Most silos in this country are made of wood, but the high price of lumber has led to the use of other materials for all kinds of farm buildings. Experiment station workers have been investigating the desirability of using earthen and metal substances for silo construction. The cross section of a homemade combination of stone and stave silo in Baltimore County, Md., is shown in figure 7. Staves

20 feet long are set on a stone pit 8 feet deep and 14 feet in diameter, making a total height of 28 feet. The details of construction are as follows:

The staves on outside are chestnut, 6 inches wide, nailed on vertically 16 feet long, and 4 feet nailed above. The 4-foot pieces are nailed on so as to lap on the 16-foot pieces; allowing the water to run off.

The interior is vertically lined with 6-inch chestnut, tar paper placed, and again lined with 6-inch chestnut, joints being broken, then the vertical laths are placed, followed with horizontal, and then plastered with cement. The bottom is cemented in saucer shape. This silo is not affected by atmospheric conditions. The cement is not thick enough to cause it to sweat, and it is as perfect a preserver as the stone silo, there being no decay from sweating. This manner of construction is the only perfect combination silo that was found. The stone and frame work remain flush, thus allowing the silage to settle evenly, which is not the case in the stave silos, as the silo has to be placed in the center of the wall. If placed too near the pit, the shrinkage will allow the hoops to pull the staves to a smaller diameter than that of the pit and thus cause a leak at the foundation, this unevenness allowing the silo to fall or blow over. Every other space between hoops is a door; paper is used between door and joint. Stave silos with hoops ought not to be used as a combination silo.

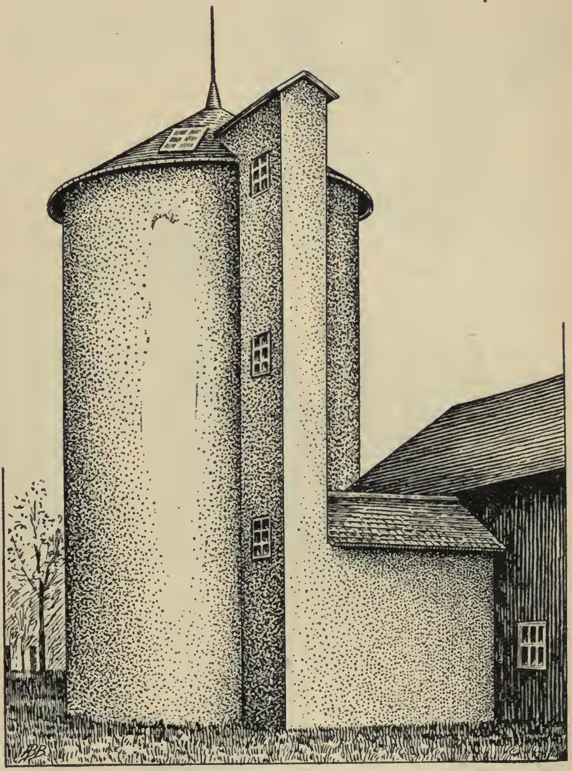

FIG. 9.—Double wall concrete silo.

The following is a list of the material required:

150 pieces ½ inch by 3 inch by 16 foot white oak for hoops.

50 pieces 1 inch by 6 inch by 16 foot chestnut staves	outside.
50 pieces 1 inch by 6 inch by 4 foot chestnut staves	
50 pieces 1 inch by 6 inch by 16 foot chestnut staves	inside first course.
50 pieces 1 inch by 6 inch by 4 foot chestnut staves	

One 16-foot piece nailed from top and 4 foot at bottom. Next stave 16 feet from bottom and 4 feet on top.

900 square feet of tar paper.

50 pieces 1 inch by 6 inch by 16 foot chestnut staves	inside second course.
50 pieces 1 inch by 6 inch by 4 foot chestnut staves	

2,600 rough laths.
20 pieces 2 inch by 4 inch by 16 foot rafters for roof.
200 feet 1 inch by 6 inch sheathing.
2,000 shingles.
18-inch stone wall.
24 perch of stone or concrete.

Doors are concave, built of staves, lined with paper, placed on two concave battens.

It may be questioned whether steel silos will come into general use. Galvanized iron is an excellent method of protecting a wooden silo when located out of doors. Many stone silos have been built, but some care must be taken to make the inside walls smooth. Cement mortar should be used and the walls must be reenforced by building steel bands into the wall.

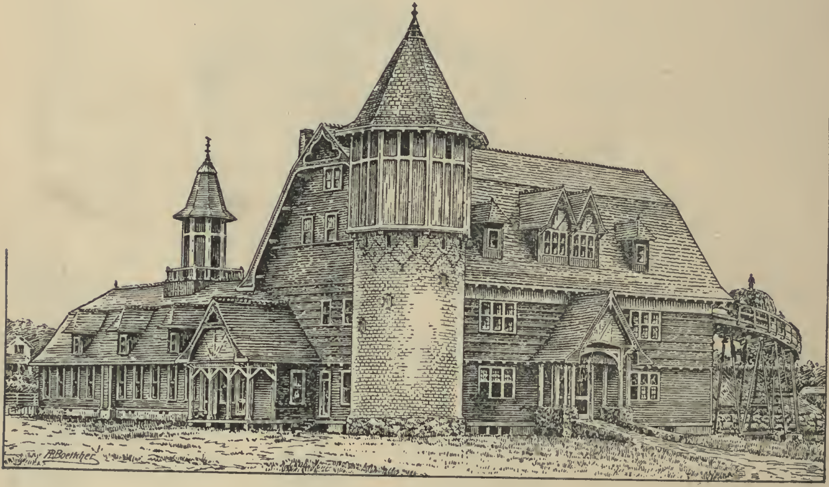

Fig. 10.—Dairy barn and stock-judging building, erected in 1898.

Clay pipe silos are giving good satisfaction, but are expensive. The tubes are set on end with the slots interlocking. Steel bands or hoops are placed around the wall and then plastered smooth with cement plaster. Rectangular building tile is recommended by the Iowa Station as a good material for silo construction. Cement block silos have been satisfactory when reenforced by steel within the walls. The inside of the silos should be plastered. The block is hollow and this prevents freezing. Brick silos are successful, but like the cement block must be reenforced in some way. Figure 8 shows a special form of double-wall brick silos.

The single-wall concrete silo is the most common style of construction. The thickness of the walls of silos now in use varies from 6 inches at the bottom to 4 inches at the top for the lightest wall to a wall 2 feet in thickness, which is the heaviest of which the section has record. Six inches seems to be the most desirable thickness for common sizes of silos under existing practice. The walls might be made lighter at the top, but the saving of material would hardly balance the trouble of varying the size of the forms. The double wall concrete silo at present is made only with a patented form. Figure 9 illustrates a double wall concrete silo made by forms owned by the Farmers Cooperative Concrete Silo Company. The inner wall is 5½ inches thick, the outer wall 3½ inches thick, and the two tied together with steel ties with a 3-inch air space between. Circulation is prevented by inserting horizontal tar paper partitions every 3½ feet. This construction, besides being as satisfactory as the single-wall method, places it entirely above any criticism in regard to freezing. The patent forms being of steel plate enable a very smooth job to be secured.

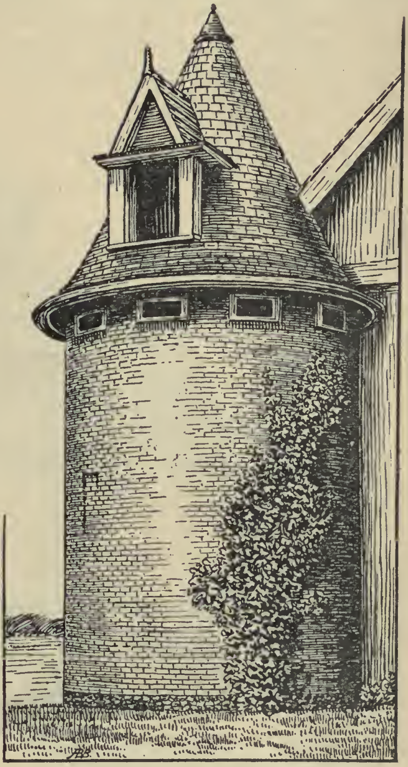

FIG. 11.—Brick silo, Iowa State College.

THE APPEARANCE OF THE SILO.

The silo as sometimes constructed is anything but an ornament to the farm. The situation and the style of architecture of the other buildings must be considered if the farmer takes pride in making his surroundings attractive. Figures 10, 11, and 12 show what may be done with the silo to make it an ornament instead of a disfigurement to the farmstead.

A CHEAP AND EFFICIENT STERILIZER.[a]

In a recent bulletin of the North Carolina Station, Prof. John Michels calls attention to the fact that "all vessels and appliances used in the handling of milk, cream, and butter should be rendered sterile after washing, either by placing them in boiling water for about five minutes or by steaming them for an equal length of time."

Small dairies without boilers should sterilize with hot water, but the larger dairies will find it advantageous to use a steam boiler and sterilize with steam. To perform this operation efficiently, it requires a closed steam chest large enough to hold everything that is to be sterilized. Sterilizers of this type are usually constructed of concrete, or brick and concrete, and are provided with a heavy iron door, this being large enough to admit a truck bearing the pails, cans, bottles, etc. Still other sterilizers of this type are constructed of galvanized iron or boiler plate, and all permit of sterilizing under more or less pressure.

The principal drawback to these various steam sterilizers is the high cost, which renders their use by the smaller dairymen almost prohibitive. After considerable experimentation and study, the writer has succeeded in constructing an efficient sterilizer which will cost only about one-third as much as the cheapest sterilizer of the type just mentioned. The construction of this new sterilizer, whose inside dimensions are 7 feet long by 2¼ feet deep, by 2¼ feet wide, is very simple. (See fig. 13.)

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[a] Compiled from North Carolina Sta. Bul. 198.

Essentially, it is a rectangular concrete tank with a wooden cover, which is lined with zinc. The sides and bottom are 5 inches thick and are built of concrete, which is made up of one part cement, two parts sand, and two parts coarse gravel. A thin coat, consisting of one part cement and two parts sand, is used as an inside finish. A piece of 2 by 4 studding is placed around the top of the tank and is secured by six ½-inch iron rods, 2 feet long, embedded in the concrete walls, one being placed at each corner, and one on either side midway between the corners. This arrangement not only strengthens the tank, but also makes the cover fit tighter.

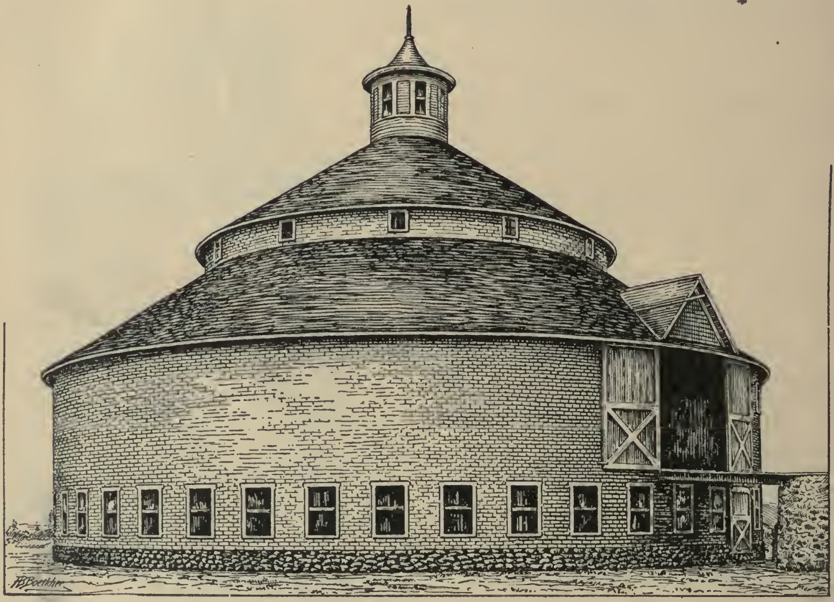

FIG. 12.—A circular dairy barn with silo in center 24 feet in diameter and 45 feet deep.

The cover consists of two thicknesses of 1⅛-inch tongued and grooved flooring 3½ inches wide. The upper boards run lengthwise and the lower crosswise of the tank. The lower boards fit into a shoulder projecting from the base of the 2 by 4 studding. The entire inside portion of the cover is covered with zinc. To insure additional tightness of the cover, a layer of asbestos is placed on top of the 2 by 4's. A safety valve, set at 10 pounds pressure, is inserted through the top of the cover at the most convenient place. An outlet for condensed steam is provided at the bottom.

The cover is raised and lowered in the same manner as that of the ice box described on page 29. The cover is strengthened by running three pieces of 2 by 4 studding crosswise of the tank, one at the middle and one at either end. The hinges, by which the cover is fastened, are attached to these 2 by 4 pieces, as shown in figure 13.

The following is an itemized statement of the approximate cost of the material of this sterilizer when the inside dimensions are: Length, 7⅓ feet; width, 2¼ feet; depth, 2⅓ feet:

2 barrels of Portland cement	$5.20
20 feet of 2 by 4 studding	.30
110 feet of 1⅛ tongued and grooved flooring, 3½ inches wide	4.40
4 hinges	.40
5 pounds nails	.20
6 ½-inch iron rods 2½ feet long	1.20
3 hasps	.30
20 square feet zinc	1.75
Ball and lever safety-valve	1.00
3 pounds sheet asbestos	.30
Total	15.05

The more extended use of efficient sanitary appliances on the farm should be encouraged, and this is most effectively done by indicating, as Professor Michels does in this case, cheap and simple methods of constructing such appliances. More sanitary methods of handling articles of food and drink would be more practicable and more generally used on the farm if some such convenient means of sterilizing appliances and utensils as Professor Michels describes were always at hand.

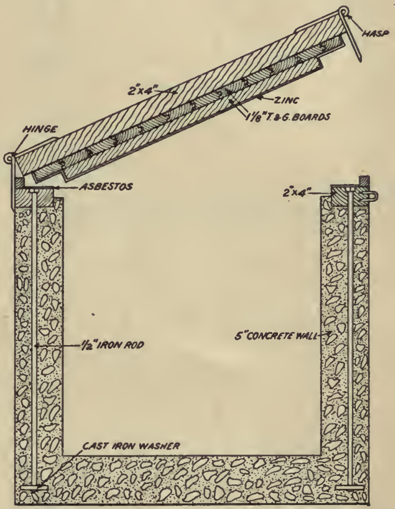

FIG. 13.—Cross section of sterilizer.

A CHEAP AND EFFICIENT ICE BOX.[a]

There is probably no need which is so severely felt on many farms, particularly in the South, as that of suitable cold storage for the preservation of meat, dairy products, and other food supplies, and as Prof. John Michels, of the North Carolina Station, points out, "cold storage of some kind is indispensable to a well-equipped dairy. Many, however, lack this essential, probably largely owing to the high cost of commercial refrigerators."

Professor Michels describes the construction of an easily made, cheap, and efficient ice box suitable for dairy purposes as follows:

The construction of the box shown in figure 14 consists essentially of two boxes separated by 1-inch strips placed at intervals of about 1 foot. Double thickness of building paper is placed on both sides of the strips and tacked to the boxes. A

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[a] Compiled from North Carolina Sta. Bul. 198.

1-inch strip 2 inches wide covers the upper space between the 1-inch strips, thus making a dead-air space between the two boxes. The construction of the cover is the same as that of the bottom, with the exception that there is a flange at the front and sides of the cover.

The sides, bottom, and cover of the refrigerator are built of ¾-inch tongued and grooved lumber 5½ inches wide. The ends are constructed of 1⅛-inch tongued and grooved flooring 3½ inches wide. The inside of the ice box is lined with galvanized iron. To insure tightness, a layer of felt is tacked around the box and cover where the two meet. The four vertical edges of the refrigerator are tightened and strengthened by tacking over each a double layer of paper, which is covered with two 6-inch boards.

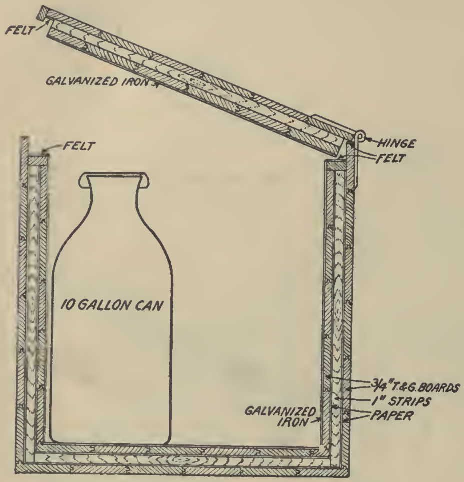

FIG. 14.—Cross section through ice box.

A heavy weight attached to a ½-inch rope running over a pulley fastened to the ceiling raises the cover and holds it open when desired. A short piece of rope with a hook attached is used to counterbalance the weight by hooking to the side of the box, thus allowing the full weight of the cover to rest on the box.

A short piece of ½-inch gas pipe is inserted through the bottom of the box to provide drainage, the outlet of this pipe being immersed in a cup of water to prevent entrance of air into the box.

The entire construction of the ice box is so simple that anyone with a little knowledge of carpentry can readily build it.

The inside dimensions are: Length, 7⅓ feet; width, 2¼ feet; depth, 2⅓ feet. An itemized statement of the cost is as follows:

200 feet ¾ inch by 5½ inch by 16-foot tongued and grooved lumber	$4.00
54 feet 1⅛ inch by 3½ inch by 16-foot tongued and grooved lumber	2.16
168 feet 1 inch by 1 inch by 12-foot strips	1.26
4 hinges	.60
½ yard felt	.63
15 feet ½-inch rope	.30
2 strong hooks	.10
1 2-inch iron pulley	.50
Carpentry work, 3 days	6.00
Complete lining with galvanized iron	11.25
500 square feet building paper	.60
Total	27.40

Commercial refrigerators of equal capacity and no greater efficiency will cost from $60 to $100, or about three times as much as the refrigerator above described.

A test of this ice box for six days with an average of 200 pounds of ice in the box showed that an average temperature of 39° F. was maintained within it, with an average daily consumption of 40½ pounds of ice, while the temperature of the room in which the ice box was kept averaged 74° F.

When 22 gallons of milk, which had been cooled to 45° F., were stored in the box eight hours daily with the other conditions as above, the average daily ice consumption for six days was 49 pounds, and the average temperature of the box 40° F.

While this box is designed especially for dairy use, it may easily be adapted to other cold-storage purposes, and so extend its usefulness on the farm.

THE POWER LAUNDRY FOR THE FARM.[a]

In an extended article recently prepared for the State Dairy and Food Commission of Missouri by Prof. R. M. Washburn, who was then commissioner, valuable suggestions are made for the planning and convenient construction of barns with reference to location, hygienic conditions, interior arrangement, and conveniences. Special stress is laid on the use of power for running a feed mill and other appliances, and the use of boilers for supplying hot water and other similar equipment essential for satisfactory dairy farms. The modern cleanly, convenient, and hygienic dairy barn means a great deal of additional work for the farmer's wife and her helpers, for white suits must be washed and there is a general increase in laundry work and similar work. It is only just that these added burdens should be offset by more conveniences and labor-saving devices. In general, it is not true that the farm home has kept pace with the rest of the farm in the adoption of improved methods of labor-saving devices and other conveniences.[b]

Professor Washburn's plans for a model dairy barn include a laundry, and interesting figures on the cost of equipment, the length of time the equipment may be expected to last, and similar matters are given. It has been suggested that a laundry such as he proposes might be used by a number of families in the neighborhood on the payment of a small fee and prove of great value to the adjacent farm community. Such ideas of cooperation applied to rural life are interesting as well as valuable and an indication of a means by which the farm housewives' labors may be lessened in a number of ways. A cooperative bakery or laundry seems as practical as the cooperative creamery which is now so common.

Professor Washburn writes on the subject of the farm laundry as follows:

> A laundry provided with stationary washtubs, with washer and wringer for power use, is an innovation. But why should not the woman of the farm be provided with modern appliances? Why should she be compelled to toil as her great-grandmother did? The farmer no longer reaps with a sickle, or even with a cradle. He rides his plow, and often his harrow. He rides his grain drill and corn planter and corn cultivator. He rides his grain harvester and his corn harvester. He loads hay by machinery and pitches it into the barn by horse power. The time is come when it

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[a] Compiled from Ann. Rpt. State Dairy and Food Commissioner Missouri, 1 (1907), pp. 129–165.

[b] The general question of conveniences in farm homes has been discussed in Farmers' Buls. 270, 296, 317, and 342.

is positive cruelty to compel, or even allow, the woman to toil on without running water or machine power in the house. The same steam, water, and sewage system that must be present for the dairy will take care of the laundry. The same power used for grinding feed and separating milk and pumping water and sawing wood will turn the washer and the wringer. Prices will vary somewhat, but the following will be a guide to the cost of equipping such a room:

Equipment and cost of a farm laundry.

Equipment.	Dimensions.	Horsepower required.	Length of service.	Approximate cost.
Stationary tubs	3 compartments, each 28 by 25 by 17 inches.		20 to 30 years	$30
Power washer	24 by 32 inches	One-half	10 to 15 years	55
Power wringer	18 by 24¾ by 30 inches	do	15 to 20 years	40
Piping and connections			10 to 20 years	5
Drying room (¾-inch steam piping)			do	10
Total				140

The investment of $140 for one year at 7 per cent equals $9.80; deterioration, assuming that they will require to be replaced every fifteen years, equals $9.35 per year, or a total of $19.15, or, say, $20 per year, or 38 cents a week; add to this 10 cents more for gasoline used by the engine. If the farmer were compelled to kill and dress two hogs every week throughout the year he would think nothing of spending 50 cents a week for machines which would save so much labor and enable him to do more work in less time. A power ironer costing about $60 may be added, if desired. Such a laundry is to be desired, also, because it will practically insure clean garments worn by the milkers. A drying room, about 6 by 12 feet, located between the dairy room and the laundry room, provided with steam pipes for heating, will cost very little, and will insure quick, clean, and easy drying in any weather. A power laundry like this may be rented to the neighbors for, say, 50 cents per day, they to come over and do the work. Such an arrangement will in a measure lighten the burden now resting so heavily on the woman of the farm.

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